DTE Electric Company

Colfax Peaking Facility

Startup, Shutdown, Malfunction (SSM) and Continuous Parameter Monitoring System (CPMS) Plans

REVISION #1

Updated By:

DTE Electric Company

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TABLE OF CONTENTS

List of Figures

List of Tables

ATTACHMENTS

Appendix A - Dynalco Catalyst Monitor Programming Manual

Appendix B - Drawings and Specs

Appendix C - PSI Catalyst Operation and Maintenance Manual

Appendix D - GM Engine Operating Manual

Appendix E - Peakers Catalyst Alarm Response Process Map

Appendix F - AST5100 Low Differential Pressure Transmitter

Appendix G - Duro-Sense Thermocouple

Appendix H - Procedure Responding to Catalyst Alarm

SECTION 1: INTRODUCTION

1.1 Purpose and Requirements

This document includes the systems and procedures for the DTE Electric Company (DTE) peaking units located at 4025 Gregory Road in Fowlerville, MI 48836-9211, hereafter referred to as the Colfax Peaking Facility (SRN B2795). These remote peaking units are maintained by the Peakers Group within DTE and are diesel-fired reciprocating internal combustion engines (RICE). Each of these engines are subject to the requirements of the National Emissions Standards for Hazardous Air Pollutants (NESHAP) for Source Categories, 40 CFR Part 63. These regulations are referred to as the MACT standards, and the applicable rules for the RICE are contained in 40 CFR Part 63, Subpart A (the General Provisions applicable to all Part 63 source categories) and Subpart ZZZZ.

These RICE are required to be equipped with emission control devices and associated monitoring equipment. Monitoring parameters must be implemented for each control device and must demonstrate compliance with the standards. A source that is required to use a Continuous Monitoring System (CMS) for measurement of the above mentioned operating parameters must also develop and implement a CPMS quality control program, pursuant to 40 CFR 63.6625(b)(1) and 63.8 (d).

A Startup, Shutdown and Malfunction (SSM) plan has been developed and implemented in order comply with the specific startup, shutdown and malfunction requirements of 40 CFR 63 Subpart ZZZZ. This plan can be found in Section 4 of this document. This SSM plan does not address the general SSM plan requirements of 40 CFR 63 Subpart A, as they are not applicable to Colfax Peaking Facility, pursuant to Table 8 of 40 CFR 63 Subpart ZZZZ.

1.2 Plan Maintenance and Updates

DTE maintains a complete copy of both the CPMS and SSM Plan (Plan) onsite. Copies of the Plan are maintained in the control room, or at other operations areas onsite. DTE has the overall responsibility to ensure that the Plan is maintained and updated as required by the rules. Environmental Management & Safety (EM&S) works with Operations/Maintenance personnel to obtain the information needed to maintain and update the Plan. Specific requirements governing maintenance for the CPMS and SSM plans can be found as a subpart in their respective sections.

1.3 Site Overview

The peaking units located at this facility were manufactured by GM Power Electro-Motive Division of La Grange, Illinois with a rating of 2.5 Megawatts (MW) and a Maximum Load of 2.75 MW. The site consists of five identical units. See Table 1.1. The site also maintains a 30,000-gallon aboveground storage tank (AST) containing diesel fuel for the generators. When all five units are on, the site uses approximately 800 gallons per hour. A facility layout is provided in Figure 1.1.

Table 1-1: Colfax Peaking Facility Emission Unit Inventory

Location Title	Unit ID	Manufacturer	Model Type	Serial No.	Installation Date	Rating (MW)
Colfax Peaking Facility	11-1	GM Power	MP-45-B	63785	July 1969	2.5
	11-2	GM Power	MP-45-B	63787	August 1969	2.5
	11-3	GM Power	MP-45-A	63783	July 1969	2.5
	11-4	GM Power	MP-45-B	63784	July 1969	2.5
	11-5	GM Power	MP-45-B	63786	August 1969	2.5

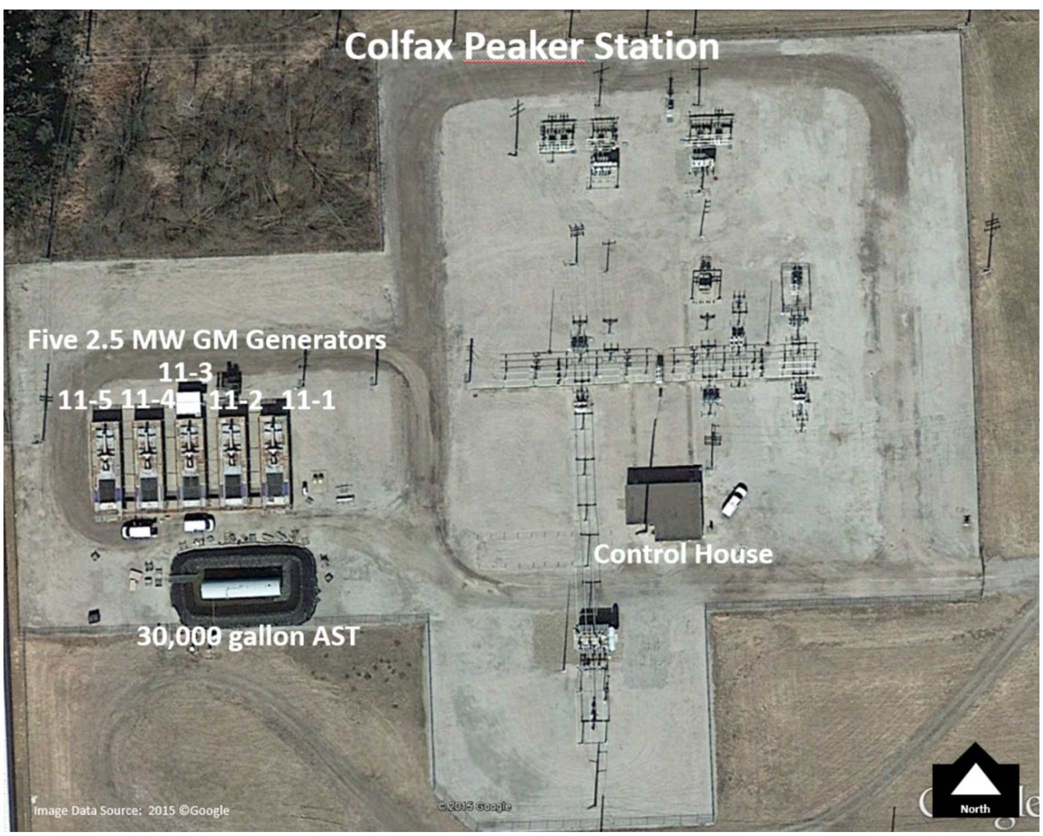


Figure 1-1. The facility consists of five 2.5 MW generators, a 30,000-gallon aboveground storage tank (AST), a control house, and a substation.

SECTION 2: PROCESS DESCRIPTION

DTE remotely operates multiple peaking facilities used during peak power demand times to provide additional power to the grid at predetermined locations. The remote peaking facilities operate diesel-fired reciprocating internal combustion engines (RICE). Each stationary RICE is equipped with a diesel oxidation catalyst (DOC) for the purpose of reducing emissions during operation. Included with this system is a continuous parameter monitoring system (CPMS) consisting of DOC monitoring points that record: control device inlet gas temperature, pressure drop across the catalyst bed, and date / time stamps of all records. These data points are then archived by DTE's PI system.

SECTION 3: CONTINUOUS PARAMETER MONITORING SYSTEM PLAN (CPMS)

3.1 Monitoring Plan

This monitoring plan addresses the monitoring system design, data collection, and the quality assurance and quality control elements outlined in the paragraphs 40 CFR 63.6625(b)(1) and in § 63.8(d). Each CPMS is installed, operated, and maintained according to procedures in this monitoring plan.

3.1.1 Equipment Performance Criteria and Design Specifications

The Dynalco Catalyst Monitor (Catalyst Monitor) provides continuous monitoring of catalyst inlet temperature and differential pressure, which is mandated by RICE NESHAP on diesel ignited engines. This monitoring system reads up to six input channels, calculates differential values, provides alarm / shutdown outputs, as well as allows all parameters to be logged to internal flash memory. Internal flash memory may be remotely accessed via the PI computer program or downloaded directly from the unit.

The Catalyst Monitor is in "stopped" mode until a run indication is sensed by either a contact closure or magnetic pickup input. Once the "running" mode is sensed, the Catalyst Monitor reads all six channel inputs at a rate of 100 milliseconds per channel. Additionally, the temperature sensor has an appropriate sensitivity of 2.8 degrees Celsius (minimum tolerance), or 1 percent of the measurement range, whichever is larger. If an input crosses an over or under threshold (See the Table 3-1), the unit will show a flashing red LED on the front panel of the monitor, as well as initiate an output trip (solid-state relay) that can be used for alarm or shutdown. Whenever a trip threshold is crossed the Catalyst Monitor stamps the event with a date and time. These events are also logged by the Peaker Operator (DTE employee) and the System Operations Center (SOC) staff. The monitor logs the last ten events for each channel input. The Catalyst monitor's operating manual is included in this report as Appendix A.

Once the initial system configuration is complete, the Catalyst Monitor will set off an alarm when channel or differential values are above or below the limits specified in the set-up procedure (See Table 3-1). The Catalyst Monitor allows the user to configure any one channel to monitor the catalyst inlet temperature based on a 4-hour rolling average per the RICE NESHAP requirement. Once set up, this channel will log the inlet temperature at 15-minute intervals while the engine is running. In addition to inlet temperature, the Catalyst Monitor logs the catalyst differential pressure at defined intervals.

Table 3-1: Diesel Oxidation Catalyst Alarm Thresholds

Monitored Parameter	Malfunction Threshold
Pressure drop across the catalyst	Less than 2 inches of water
Engine exhaust temperature at catalyst inlet	1350 °F ≥ Temperature ≥450 °F

3.1.2 Sampling Interface

Catalyst bed inlet temperatures are taken via thermocouple located at the inlet to the DOC. Pressure drop is calculated via pressure measurements at the inlet and outlet of the DOC.

3.1.3 Equipment Performance Evaluations

Performance evaluations, system accuracy audits and other audit procedures are conducted in accordance with the Catalyst Monitor manual and manufacturer recommendations. These performance evaluations are conducted on a calendar year basis.

American Sensor Technologies Inc. does not have a documented evaluation process and stated that there is no calibration for their AST5100 Low Differential Pressure Transmitter. However, based on the parameters outlined in Appendix F, the unit is functioning properly.

Duro-Sense also does not have a documented evaluation process for their K-type Thermocouple. However, through consultation with Duro-Sense, it was determined that a verification will be conducted annually. This verification will consist of placing another thermometer or thermocouple in the same medium as the thermocouple and comparing the temperature readings. The results should be within the standard specification limits indicated in Appendix G.

The Peakers Group will ensure that these performance evaluations are conducted annually, documented, and supplied to EM&S.

3.1.4 Operating and Maintenance Procedures

The peaking facility keeps the necessary parts for routine repairs on the Catalyst Monitor equipment readily available in the Control House in accordance with 40 CFR 63.8(c)(1)(ii). Refer to Catalyst Monitor manual (Appendix A) for a spare parts list. The Catalyst Monitor was installed in accordance with the Manufacturer's written recommendations for installation, operation, and calibration of the system. Information on the Catalyst Monitor installation, operation, calibration, and design can be found in the Catalyst Monitor manual or operation records available from the Peakers Group or EM&S.

3.1.5 Reporting and Recordkeeping

DTE maintains the following records for the Catalyst Monitor System to ensure compliance with 40 CFR 63.10(c) and (e):

- Catalyst inlet temperature and pressure drop;
- The date and time identifying each period during which the CMS was inoperative except for zero (low-level) and high-level checks;
- The date and time identifying each period during which the CMS was out of control;
- The specific identification (i.e., the date and time of commencement and completion) of each period of excess emissions and parameter monitoring exceedances, as defined in the relevant standard(s), that occurs during startups, shutdowns, and malfunctions of the affected source;
- The specific identification (i.e., the date and time of commencement and completion) of each time period of excess emissions and parameter monitoring exceedances, as defined in the relevant standard(s), that occurs during periods other than startups, shutdowns, and malfunctions of the affected source;

- The nature and cause of any malfunction (if known);
- The corrective action taken or preventive measures adopted;
- The nature of the repairs or adjustments to the CMS that was inoperative or out of control;
- The total process operating time during the reporting period; and
- All procedures that are part of a quality control program developed and implemented for CMS under § 63.8(d).

All performance evaluations are kept on record for the life of the affected source or until the affected source is no longer subject to § 63.8(d)(3). The records are available for inspections or upon request. DTE keeps previous versions of the performance evaluation plan on record for a period of 5 years after each revision of the plan.

The facility also maintains records of maintenance conducted on all stationary RICE located on-site in order to demonstrate compliance with operating procedures and the equipment maintenance plan.

SECTION 4: STARTUP, SHUTDOWN, MALFUNCTION (SSM) PROCEDURES

It is the facility's obligation to ensure that each stationary RICE, including its associated oxidation catalyst and monitoring equipment, is operated and maintained, in such a way that minimizes emissions (63.6605).

This Startup, Shutdown, Malfunction (SSM) plan complies with the specific startup, shutdown and malfunction requirements of 40 CFR 63 Subpart ZZZZ. This SSM plan does not address the general SSM plan requirements of 40 CFR 63 Subpart A (63.6(e)), as they are not applicable to this peaking facility pursuant to Table 8 of 40 CFR 63 Subpart ZZZZ.

In addition to the procedures below, each stationary RICE minimizes emissions by conducting performance tests as required every 8760 hours or 3 years, whichever comes first. Test plans containing the methodology and schedule are maintained in EM&S SharePoint, along with the performance test results.

4.1 Startup Procedures

A startup is defined as "the setting in operation of an affected source or portion of an affected source for any purpose." [§63.2]. Per ZZZZ, an engine startup is "the time from initial start until applied load and engine and associated equipment reaches steady state or normal operation. For stationary engine with catalytic controls, engine startup means the time from initial start until applied load and engine and associated equipment, including the catalyst, reaches steady state or normal operation." [63.6675].

This procedure has been set to minimize the engine's time spent at idle and minimize the engine's overall startup time in order to allow for the appropriate and safe loading of the engine. At all times, including startup, the engine exhaust is vented through the oxidation catalyst to reduce emissions. Under EPA regulation, startup time is not to exceed 30 minutes (63.6625(h)), after which time non-startup emission regulations apply [§63.6600(d)(Table 2d(3)(a-b)]. Additionally, excessive idling at Startup may result in DOC error report (i.e., the temperature and pressure values violate the conditions in Table 3-1).

<u>Normal Start</u>

The facility initiates the startup procedure of the stationary RICE from the Control Room at Colfax, either at their own initiative, or by the SOC's request. These are the only Peakers in the network with DOCs that cannot be initiated by the SOC. During a normal start, once initiated, the startup consists of a rolling unit start where each unit has a 90 second start and idle delay, then goes in to a 10 second acceleration, 10-20 second synchronizing period, and then a 10-30 second loading period. The maximum total startup time for the units to come to loading is 180 seconds from the time of startup initiation.

<u>Emergency Start</u>

During a deadline emergency start, a startup similar to the normal startup occurs with a rolling unit start where each unit has a 26-36 second start and oil pressure delay, 10 second acceleration, 10-20 second synchronizing period, and then the loading breaker closes once the last unit has synchronized. The maximum total startup time for a deadline emergency start is 76 seconds from the time of startup initiation.

The Engine Operating Manual contains further details on the startup procedures and is attached as Appendix D, and can also be obtained from the Peakers Group or EM&S.

4.2 Shutdown Procedures

A shutdown is defined as "the cessation of operation of an affected source or portion of an affected source for any purpose." [§63.2]

During shutdown of each engine, exhaust is vented through the existing oxidation catalyst to minimize emissions.

4.3 Malfunction Procedures

A malfunction is defined as "any sudden, infrequent, and not reasonably preventable failure of air pollution control and monitoring equipment, process equipment, or a process to operate in a normal or usual manner which causes, or has the potential to cause, the emission limitations in an applicable standard to be exceeded. Failures that are caused in part by poor maintenance or careless operation are not malfunctions." [§63.2]. Per ZZZZ, a malfunction is "any sudden, infrequent, and not reasonably preventable failure of air pollution control equipment, process equipment, or a process to operate in a normal or usual manner which causes, or has the potential to cause, the emission limitations in an applicable standard to be exceeded. Failures that are caused in part by poor maintenance or careless operation are not malfunctions." [63.6675].

Procedures for responding to an alarm are identified in the *Peakers Catalyst Alarm Response Process Map* (Appendix I) and the "Step-by-Step" procedure used by the Peakers Group (Appendix E). In general, the procedure is as follows:

Upon receiving a Peaker trouble alarm, the SOC dispatches an operator to the facility. Once onsite, the operator will evaluate the alarm to determine whether it is a nuisance alarm or an actual malfunction/system problem. If it is a nuisance alarm, the operator will acknowledge the alarm & continue operation as normal.

If the alarm is not a nuisance alarm, the operator will report to the SOC that the unit is out of control. The SOC will arrange to have the unit shut down. The Peakers Group will contact PSI to trouble shoot the alarm using the unit manual (Appendix C). Should maintenance be required, the unit will not be restarted until the situation is addressed.

All alarms and responses will be documented in the log book at the facility.

4.4 Recordkeeping and Reporting

Records are retained for all operations for a period of five years in accordance with 40 CFR 63.6660 and 63.10(b)(1).

If a malfunction occurs during the reporting period, this is included in the semi-annual ZZZZ compliance report in accordance with 63.6650(b). In accordance with 40 CFR 63.6650(c)(4), each malfunction instance will include the following:

- The number, duration, and description of the malfunction;
- Actions taken to minimize emissions; and
- Actions taken to correct the malfunction.

SECTION 5: QUALITY CONTROL PROGRAM

The owner or operator of an affected source that is required to use a CMS and is subject to the monitoring requirements of this section and a relevant standard shall develop and implement a CMS quality control program. As part of the quality control program, the owner or operator shall develop and submit to the Administrator for approval upon request a site-specific performance evaluation test plan for the CMS performance evaluation required in paragraph 40 CFR 63.8(e)(3)(i) of this section, according to the procedures specified in paragraph (e). In addition, each quality control program shall include, at a minimum, a written protocol that describes procedures for each of the following operations [40 CFR 63.8(d)(2)]:

5.1 Calibrations [40 CFR 63.8(d)(2)(i) and (ii)]

The initial calibration of the Catalyst Monitor follows the installation directions in the monitor manual. Any subsequent calibrations follow the guidelines and recommendations in the monitor manual. Procedures in the determination and/or adjustments required during calibration in order to account for calibration drifts are contained in the catalyst monitor manual.

5.2 Preventative Maintenance [40 CFR 63.8(d)(2)(iii) and (iv)]

All maintenance conducted on the monitoring system is done in accordance with the manual. A list of the spare parts needed for regular maintenance of the catalyst monitor is also included in the Catalyst Monitor manual. Maintenance records are available from the Peakers Group.

5.3 Audit Procedures [40 CFR 63.8(d)(2)(v)]

The continuous catalyst monitor system date / time stamps all data collected and stores the data in an internal database. The catalyst monitor observes the inlet temperature and pressure, calculates the differentials, and sounds an alarm in the case that an over or under threshold has been crossed. See Section 3.1.1 for more details.

Performance evaluations, system accuracy audits and other audit procedures are conducted in accordance with the Catalyst Monitor manual and recommendations. These performance evaluations are conducted at least annually.

5.5 Record Keeping [40 CFR 63.8(d)(3)]

These written procedures are kept on record for the life of the affected source or until the affected source is no longer subject to the regulations.

The Facility must complete a review and evaluation of this SSM and CPMS Plans as needed. Evidence of these reviews shall be recorded in the plan.

Revision No.	Changes	Author	Date
0	Creation of Colfax site-specific SSM & CPMS Plans per 63.6625(b)(1) **Prior to 2015, all DTE ZZZZ peaking facilities utilized one plan (SSM & CPMS Plans, created April 2013, updated December 2014)*	Tetra Tech	07/2015
1	• Added this revision tracking & changes table • Added additional references and verbiage from ZZZZ • Removed Appendix H (RICE Test Plan), as this is stored separately in SharePoint • Made general administrative & clerical updates • Replaced old company logo with new DTE logo on cover page • Added a header to Plan • Added REV1 to document in header & on title page	Lisa Fishbeck	12/10/2020

Appendix A - Dynalco Catalyst Monitor Programming Manual

DYNALCO

5450 NW 33rd Ave, Suite 104
Fort Lauderdale, FL 33309

3211 Fruitland Ave
Los Angeles, CA 90058

Catalyst Monitor

6-Channel Monitor

Programming Manual

Published: June1, 2012

System Overview

The Dynalco Catalyst Monitor is designed to address the RICE NESHAP mandate regarding continuous monitoring of catalyst inlet temperature and differential pressure on both spark-ignited and diesel engines. It is capable of reading up to 6 input channels, calculating differential values, providing alarm / shutdown outputs as well as allowing all parameters to be logged to an internal flash memory. An RS-485 Modbus link for communications to a DCS or PLC is also provided.

Additionally, the Catalyst Monitor is capable of calculating the engine catalyst inlet temperature based on a 4 hour rolling average per RICE NESHAP requirements.

Basic operation:

The Catalyst Monitor will be in "stopped" mode until a run indication is sensed. This is selectable as either a contact closure or magnetic pickup input. Once "running" mode is sensed, the Catalyst Monitor will read all inputs at a rate of 100 msec per channel. If any input crosses either an over or under threshold, the unit will invoke a flashing red LED on the front panel as well as an output trip (solid-state relay) that can be used for alarm or shutdown. Any trips will also cause the Catalyst Monitor to date / time stamp whenever a trip threshold is crossed. The monitor will log the last (10) events for each channel input.

Data Logging:

The Catalyst Monitor also allows data logging of any monitored values where they will be saved to an internal flash memory. Memory is sufficient to hold up to 500,000 data values with date / time stamp. These values can be downloaded at any time to a PC using Dynalco's download cable and Log Reader software.

User Interface

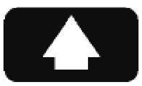
The Catalyst Monitor is configured via the keypad on the front panel which includes a graphical backlit LCD display capable of displaying alpha numeric values and custom engineering units of measure. The keypad implements a menu system, which is navigated using the up, down, left, right, enter and escape buttons. The backlight will turn off after five minutes of inactivity and will turn on when any of the keys are pressed.

Programming Overview

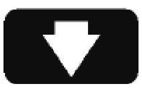
All programming is accomplished through the front keypad. Below is a brief description of each key.

Press to enter or exit the configuration screens

Press to enter or accept values



Select up



Select down

Go back one screen

Select and advance to next screen

Initial configuration consists of the following steps:

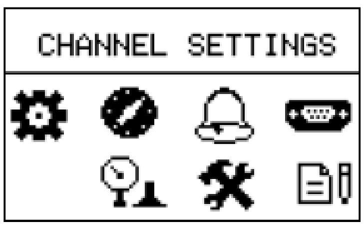
1) Setting current date / time
2) Enabling each input
3) Defining each input type
4) Defining min. & max. display values for any current or voltage inputs
5) Defining measurement display units (PSI, mV, F, C, H20, etc)
6) Setting over / under setpoint trips
7) Selecting either output 1 or output 2 (or both) for alarm trips
8) Setting either latching or non-latching for output trips
9) Defining data logging events

Programming Instructions

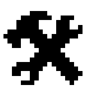
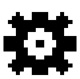
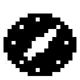
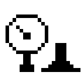
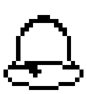
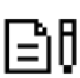
Important: ***The Catalyst Monitor must first be programmed prior to operation.***
When initially powering up the unit, the display will first indicate the firmware version and then go to the operational mode. It may also display a screen warning that the time & date need to be entered. This will be explained below.

To configure the Catalyst Monitor, first go to the main programming screen by pressing the Menu / Escape key:

The main configuration screen appears as:



The various icons are described as:

	System	- allows display customization & current date / time input
	Run Signal	- defines run status input type (if any)
	Channel	- enables each channel type and alarm thresholds
	Calibration	- defines zero & span values for DCV & mA inputs
	Alarm Logs	- allows the user to view alarm status
	Communication	- Modbus setup
	Data Log	- allows configuration of up to (10) different logging events

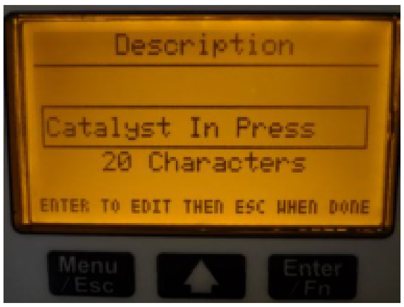
Pressing  at any time during configuration will prompt you to save the changes. Select “Yes” to save any changes made. Selecting “No” will not save changes.

Common Programming:

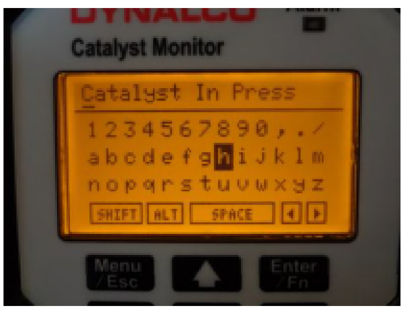
Editing Alpha Values:

The device allows text to be entered as tags for important fields. The operator can enter their own descriptive text into these fields.

When you encounter a screen with a box that requires alpha-numeric editing such as:



press  then this screen appears

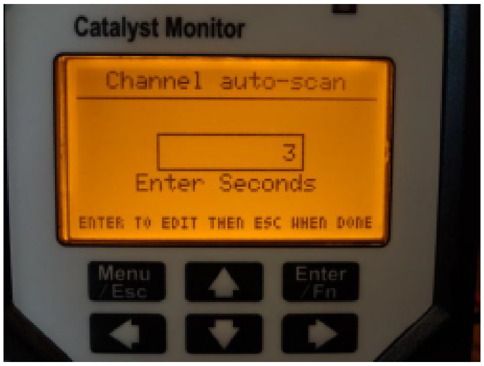


Note that the line is under the “C” on the top line.

Use the arrows to move the black highlighted cursor on the screen. Pressing the ENTER button will replace the C to an h. Moving the cursor to the bottom row selects special functions.

When alpha editing is complete, press the  to save

Editing Numeric Values:
The device allows numbers to be entered for important fields.
When you encounter a screen with a box that requires numeric editing such as:



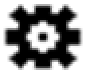
press 

then this screen appears

Use the arrows to move the black highlighted cursor on the screen. Pressing the ENTER button will add a 5 after the 3.

When numeric editing is complete, press the 

to save

Configuration of "Run Signal" 

Using the arrows on the keypad, select the "Run Signal" icon.
There are (3) run types available. The definitions are as follows:

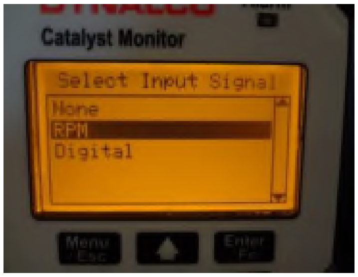
None: No run indication required. Monitoring is always active.
RPM: Monitoring is active when signal received from magnetic pickup.
Digital: Monitoring is active when contact closure (connection to ground) is sensed.

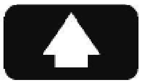
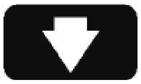
To select run signal type, use the up / down arrows to select, then press the ***right*** arrow to accept and advance to the next screen.

If **"None"** is selected, there is no other action required other than to select "escape." After selecting escape, you will be asked to select "yes" to save.

If **"RPM"** is selected, you will need to set the # gear teeth, RPM threshold and startup delay. The RPM threshold is the speed above which monitoring will be active. The startup delay allows you to delay monitoring for as many as 300 seconds (5 minutes) to allow time for all inputs to be at normal levels. If no delay is required, set to 0 seconds. The magnetic pickup input terminals are indicated on page 4.

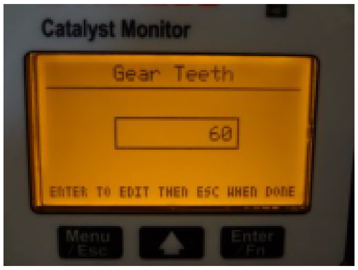
If **"Digital"** is selected, you will only need to set the startup delay (if applicable). In this mode, a run signal will be sensed with a contact closure (or short) between the magnetic pickup input terminals indicated on page 4.



 or  to select input

 Select and advance to next screen

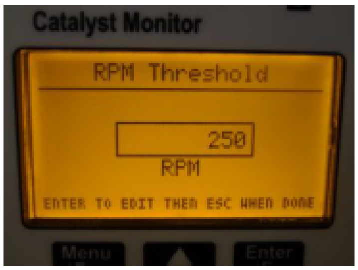
RPM Parameters



press 

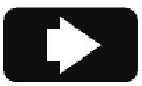
to alpha edit

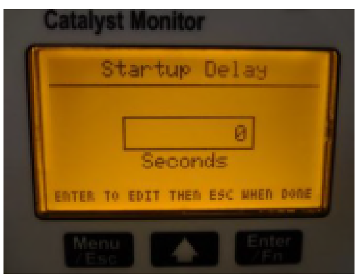
 Select and advance to next screen



press 

to alpha edit

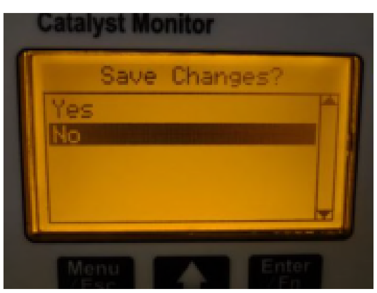
 Select and advance to next screen

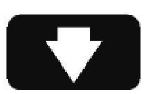


press 

to alpha edit

 Select and advance to next screen



 or  then 

Run Signal is now set

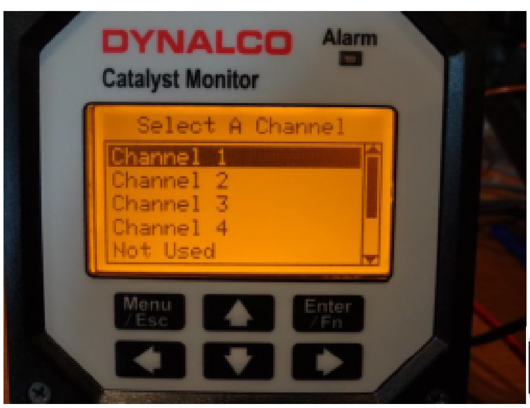
Using the arrows on the keypad, select the "Channel" icon.

Next, select the channel number to configure by pressing the up / down arrows, then pressing the right arrow to navigate and select the following:

Enable Channel	(Yes / No)
Channel Type	(0-1 V, 0-5 V, 0-10 V, 4-20 mA, J Type, K Type)
Description	(name input with up to 20 characters)
Engineering Units	(up to 3 characters, for example: PSI, mV, F, C etc…) ***Note:*** *For thermocouple inputs, you must enter either "F" or "C"*
Enable alarms	(read only or alarm?)
Alarm Type	(latching or non-latching?)
Alarm Output	(select output #1, output #2 or both)
Alarm Low	(select threshold for under-trip)
Alarm High	(select threshold for over-trip)
Alarm Reset Points	(select either the default reset value or manually set)
Alarm Reset Low	(manually set reset hysteresis for low trip)
Alarm Reset High	(manually set reset hysteresis for high trip)

Menu / Esc

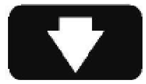
Enter / Fn



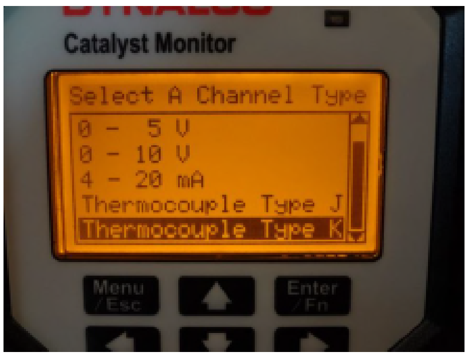
Typical Channel Set Up:
Channel 1: Pre Catalyst Temp; Thermocouple Type K
Channel 2: Post Catalyst Temp; Thermocouple Type K
Channel 3: Pre Catalyst Press; 4-20mA
Channel 4: Post Catalyst Press; 4-20mA
Channels 5&6: Not Used

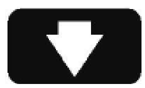
or to select Channel to Configure

Select and advance to next screen

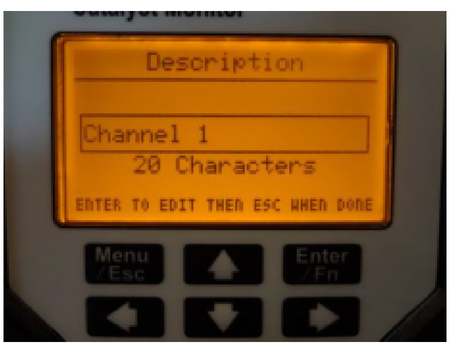
 or  to enable the channel

 Select and advance to next screen



 or  to the signal input

 Select and advance to next screen

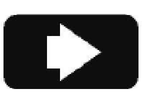


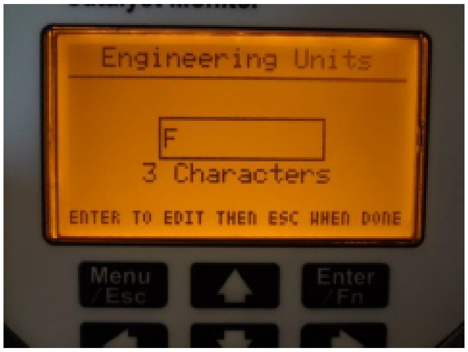
press 

to alpha edit “Pre Catalyst Temp”

When alpha editing is complete, press the 

to save

 Select and advance to next screen



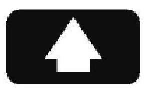
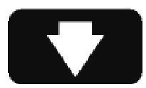
press 

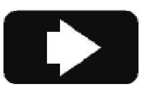
to alpha edit engineering units for the channel

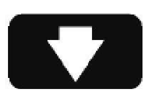
When alpha editing is complete, press the 

to save

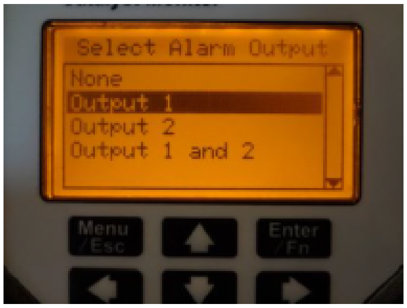
 Select and advance to next screen

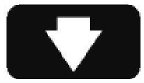
 or  to enable the alarm contacts

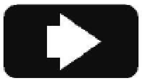
 Select and advance to next screen

 or  to select alarm contact behavior

 Select and advance to next screen



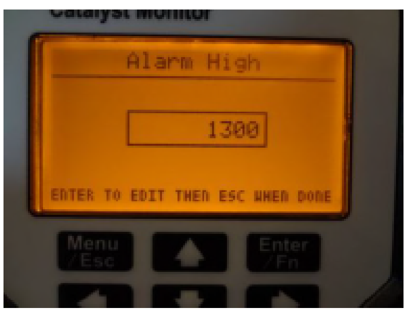
 or  to select alarm contact position

 Select and advance to next screen

press 

to numeric edit the low setpoint

 Select and advance to next screen

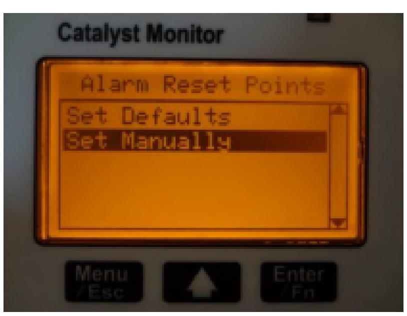


This setting also scales the bar graph on layout 2

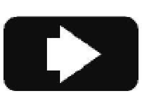
press 

to numeric edit the high setpoint

 Select and advance to next screen



 or  to select alarm reset values

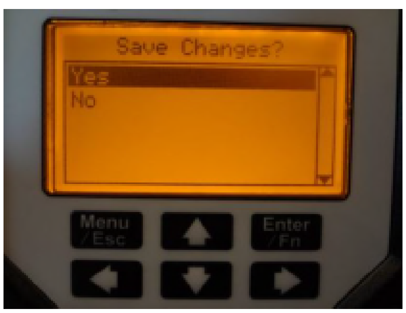
 Select and advance to next screen

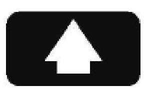
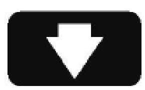
press  to numeric edit the low reset for alarm cancel

 Select and advance to next screen

press  to numeric edit the high reset for alarm cancel

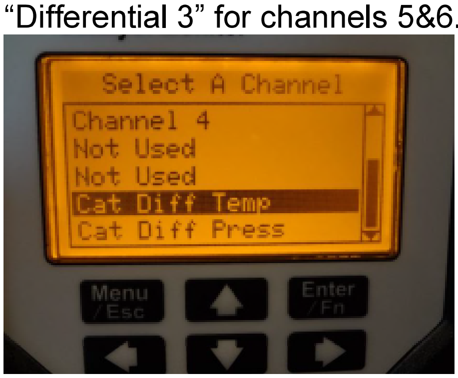
 Select and advance to next screen



 or  saves values

This completes one channel set up, redo for other required channels.

Differential calculations between channels 1&2, 3&4, 5&6 are also enabled by selecting the "Channel" icon. Enable "Differential 1" for channels 1&2, "Differential 2" for channels 3&4 and "Differential 3" for channels 5&6. These are helpful in determining catalyst health.



Differential channels program similarly to regular channels

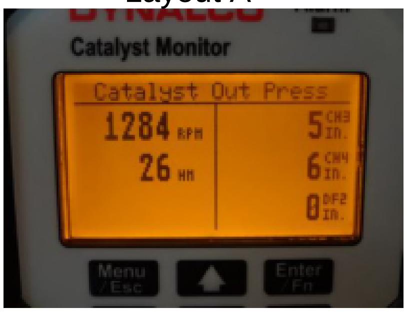
“System” Configuration

Using the arrows on the keypad, select the “System” icon.

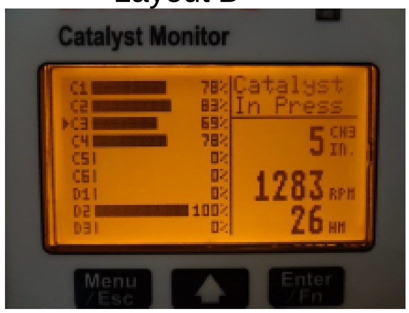
There are (3) display layouts available. Selecting layout A, B or C will define the preferred display type as follows:

Layout A: Displays groups of (2) input channels plus differential.
Layout B: Displays all inputs as bar graph plus each individual channel.
Layout C: Displays each individual channel in large format.

Layout A



Layout B



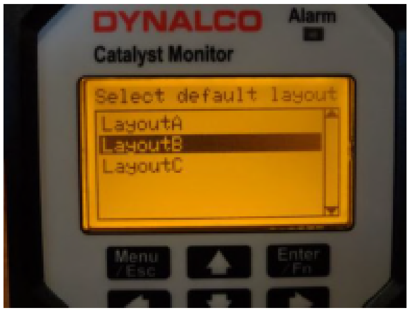
Layout C

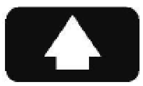
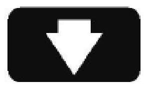
Note that you are selecting the default layout type. You will be able to change the layout during normal operation by pressing the left / right arrows.

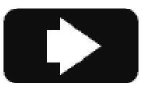
Important: *The current date and time are also programmed through the “System” icon. This is critical for proper alarm and data log information. Please note also that the date and time may need to be re-programmed if the Catalyst Monitor loses input power for over 1 week. This will be indicated by a warning upon powering up the unit.*

Any data logged to the internal flash memory will be held indefinitely even if power lost.

System Set Up Menus:

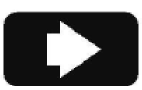


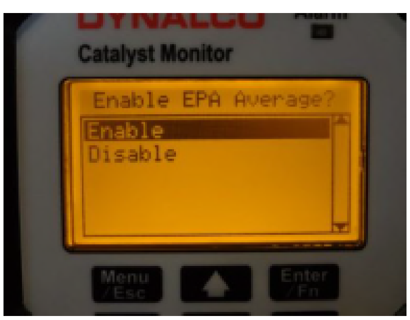
 or  to select the default layout screen

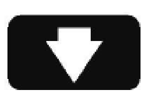
 Select and advance to next screen

press 

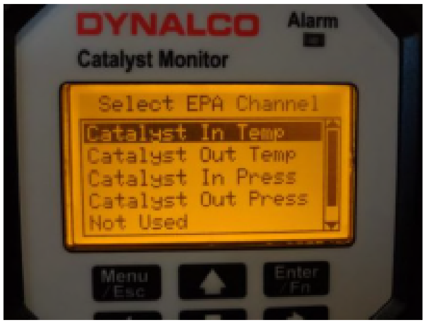
to numeric edit

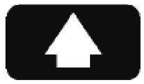
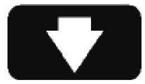
 Select and advance to next screen



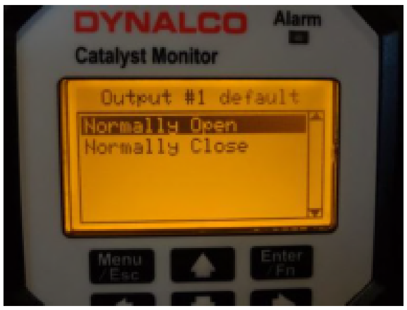
 or  to enable EPA average

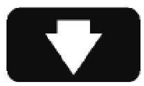
 Select and advance to next screen



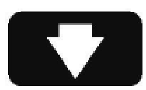
 or  selects channel for EPA average

 Select and advance to next screen

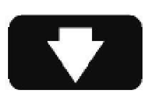


 or  sets output 1 switch

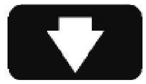
 Select and advance to next screen

 or  sets output 2 switch

 Select and advance to next screen

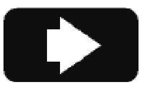
 or  sets output 2 switch

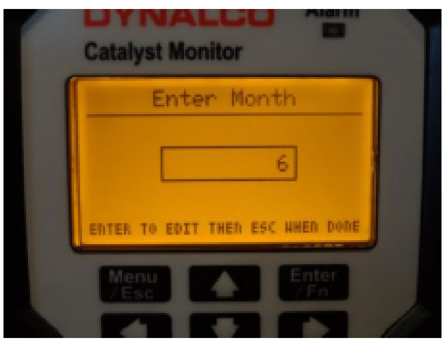
 Select and advance to next screen

 or  sets output 2 switch

 Select and advance to next screen

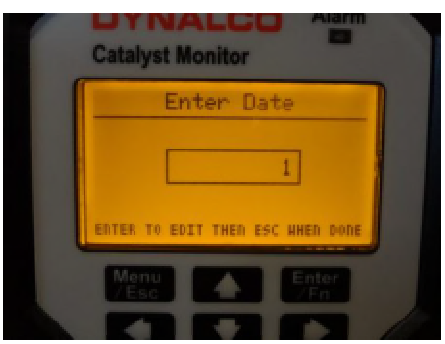
press Enter/Fn to numeric edit

 Select and advance to next screen



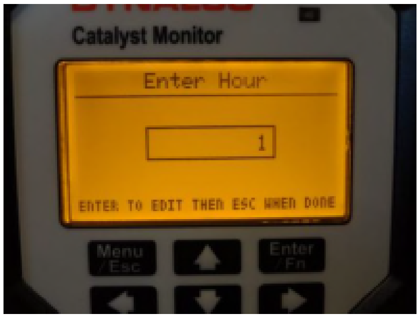
press Enter/Fn to numeric edit

 Select and advance to next screen



press Enter/Fn to numeric edit

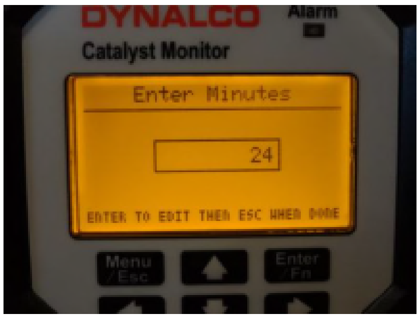
 Select and advance to next screen



press 

to numeric edit

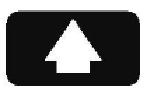
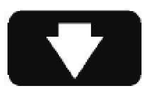
 Select and advance to next screen

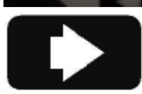


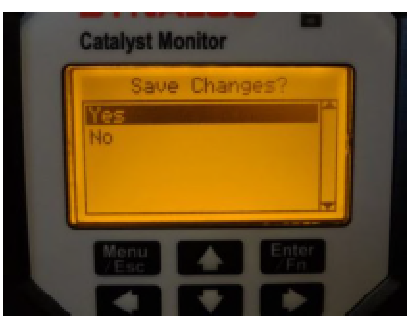
press 

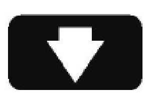
to numeric edit

 Select and advance to next screen

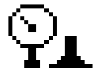
 or  sets AM/PM

 Select and advance to next screen



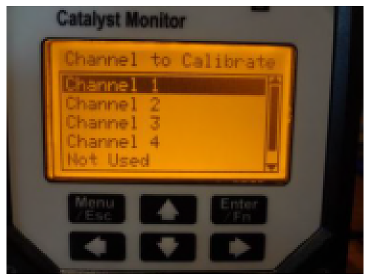
 or  saves values

This completes system set up.

Configuration of “Calibration” 

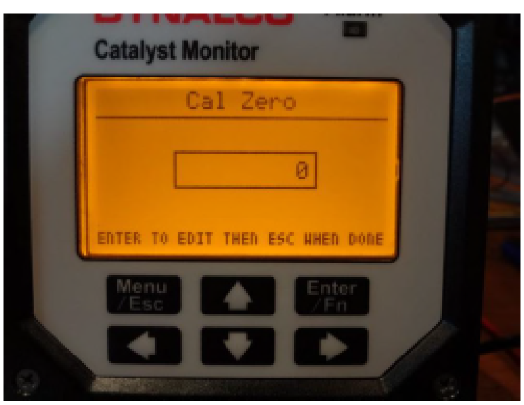
Using the arrows on the keypad, select the “Calibration” icon.

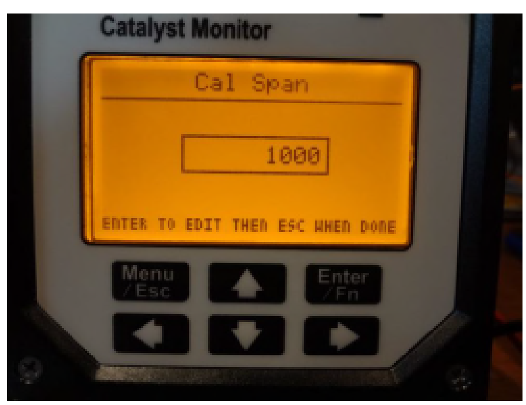
Next, select the channel number to configure by pressing the up / down arrows and pressing the right arrow to select and continue.

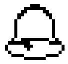


The screens allow you to define the “Cal Zero” and “Cal Span” values for any channels that are configured for 0-1 V, 0-5 V, 0-10 V or 4-20 mA inputs.

> <u>*Example*</u>
>
> *A pressure transmitter is connected to channel # 1. The transmitter has a 4-20 mA output representing a pressure input of 0 - 500 PSI. The “Cal Zero” and “Cal Span” values would be defined as:*
>
> > *Cal Zero = 0*
> > *Cal Span = 500*
>
> *Note that the “Engineering Units” would be input as PSI in “Channel” configuration above.*





Alarm Logs 

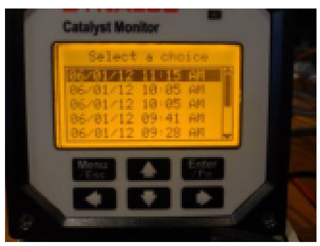
Selecting “Alarm Logs” will allow the following (2) options:

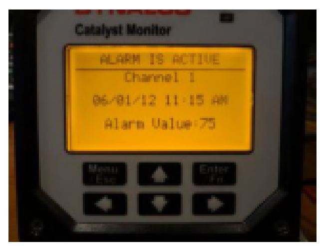
Show Active alarms:

- displays any active alarms & date / time information
- active alarms may be acknowledged by pressing “enter”
- once an alarm is acknowledged, it is placed into historical memory (see below)

Show All alarms

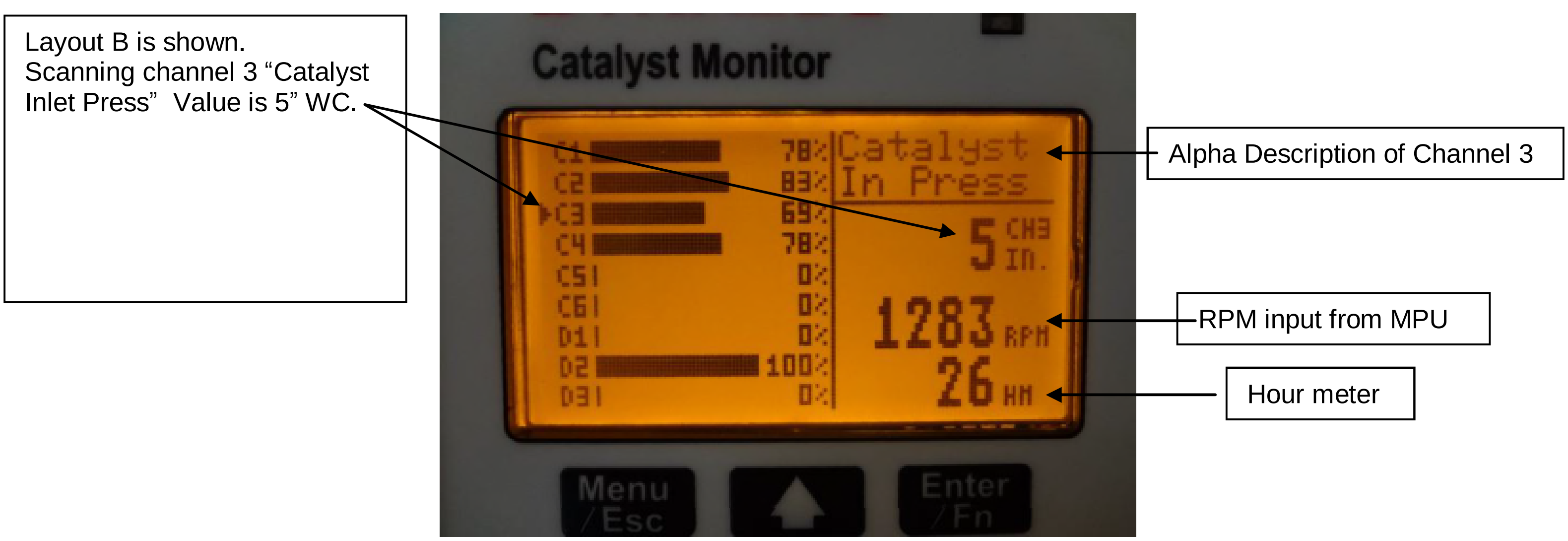
- shows historical data (last 10 alarms) for each channel with date / time stamp





Operation

Once programmed, the Catalyst Monitor will begin scanning all enabled channel inputs and will initiate alarms based on over / under threshold values configured for each channel. It is not necessary to define alarm threshold values for all channels as some may be for monitoring only.



Alarm Outputs

The Catalyst Monitor will alarm when channel values or differential values are above or below limits as specified. Alarms can be configured as either latching or non-latching. If an alarm condition is met, the red LED on the front panel will blink and the digital output(s) will trip. The alarm point name (ch1, ch2, df1, df2) that caused the alarm will be stored in memory with date/time stamp info. Non-latching alarms will reset the alarm if its value returns to normal. Latching alarms require manual resetting via the front keypad.

Selecting the alarm icon will allow you to view any active alarms as well as the history log for each channel. Once an active alarm is acknowledged, it will be placed into the history log. The history log will continuously store the last 10 alarms for each channel as well as the time & date of each alarm occurrence.

Catalyst Inlet Temperature Monitoring (per RICE NESHAP requirements)

The Catalyst Monitor will allow you to configure any one channel to monitor the catalyst inlet temperature based on a 4 hour rolling average per the RICE NESHAP mandate. To set this up, first go to the main menu, then select "System." Go to the right until you see the screen named "Enable EPA Average." Selecting "Enable" will bring you to the next screen allowing you to select which channel is monitoring the catalyst inlet temperature. Please note that once this is configured, the channel representing the catalyst inlet temperature will always display the 4 hour average, not instantaneous exhaust temperature. This temperature is only updated every 15 minutes per NESHAP requirements.

Following this, selecting the "Channel" icon in the main menu screen will allow over and under temperature alarms to be set according to the mandate.

Data logging of the inlet temperature values is explained in the next section.

Data Logging

Configuration:

The Catalyst Monitor can be configured to log any of the parameters being monitored, at user defined time intervals. The values are saved to an internal flash memory with sufficient memory to hold up to 500,000 data values with date / time stamps. These values can be downloaded at any time to a PC using Dynalco's "Log Reader" software.

The logging of any parameter is configured as an event. The Catalyst Monitor will allow up to (10) individual events to be defined.

For the RICE NESHAP requirement, the catalyst inlet temperature (based on the 4 hour rolling average) is to be logged at 15 minute intervals while the engine is running. An event can be configured to comply with this mandate.

It's also possible to configure another event that will log the catalyst differential pressure at defined intervals. Note that some users may decide to manually record this value once per month since the engine needs to be fully loaded.

Example # 1:

To configure data logging of <u>catalyst inlet temperature</u> every 15 minutes:

Using the arrows on the keypad, select the "Data Log" icon.

Next, select "Setup Log Events" and press the arrow.

The next screen will display a list of (10) events that can be configured. If this is the first event to be programmed, select "Event 1" and press the arrow.

Next select "Enable" and press the arrow.

The next screen allows you to define an "On" condition. The configuration for logging the inlet temperature does <u>not</u> require this since the "On" condition is normally defined by an "engine run" signal. See above (page 8) for the procedure for configuring the "run" signal. In this case, select "No" and press the arrow.

The next screen named "Input To Log" allows the user to select which parameter to log. Using the up / down arrows, select the input channel that is set up to monitor the catalyst inlet temperature. Press arrow.

The next screen named "Log Frequency" allows the configuration of how often (in minutes) the value is to be logged. Press enter and edit for 15 minutes. Selecting escape will return to the "Log Frequency" screen. Press the arrow and then select "Yes" to save the changes. Pressing the escape key two times will escape to the normal monitoring mode.

Example # 2:

To configure data logging of <u>catalyst differential pressure</u> after engine warm up:

(Note that this configuration will require an input signal from a magnetic pickup to sense engine running.)

Using the arrows on the keypad, select the "Data Log" icon.

Next, select "Setup Log Events" and press the arrow.

The next screen will display a list of (10) events that can be configured. If this is the second event to be programmed, select "Event 2" and press the arrow.

Next select "Enable" and press the arrow.

The next screen allows you to define an “On” condition. The configuration for logging the differential pressure will require an “On” condition defined by an “engine run” signal. See above (page 8) for the procedure for configuring the “run” signal. In this case, select “Yes” and press the arrow.

Select “Edit Compare” on the next screen and press the arrow.

Select “Compare 1” on the next screen and press the arrow.

Select “RPM” on the next screen and press the arrow.

Select “Greater Than” on the next screen and press the arrow.

Select “A Value” on the next screen and press the arrow.

On the following screen, select an RPM value that will indicate engine running. This value should be lower than the normal engine running speed and higher than the RPM defined as the “run” signal in page 8.

The next screen will ask if you want to “Edit Another?” Select “no” and press the arrow.

Press the arrow (3) more times until the screen appears as “Enter ON Delay.” Enter this number as the time delay (in seconds) following engine start when you would like to log the catalyst differential pressure. The maximum value configurable is 3600 seconds (60 minutes.) After entering the time delay, press arrow.

The next screen allows you to define an “Off” condition. In this case, select “No” and press the arrow.

The next screen named “Input To Log” allows the user to select which parameter to log. Using the up / down arrows, select the input that is defined as the catalyst differential pressure. Press arrow.

The next screen named “Log Frequency” allows the configuration of how often (in minutes) the value is to be logged. Entering 0 minutes will allow only (1) data log event following the start delay. If you wanted to continuously log the differential pressure, you would select the frequency in minutes between data logs. Selecting escape will return to the “Log Frequency” screen.

Press the arrow and then select “Yes” to save the changes.

Pressing the escape key two times will escape to the normal monitoring mode.

Downloading logged values to PC:

The hardware connection from the Catalyst Monitor to a PC is via a USB cable assembly, Dynalco p/n 270A-13020. The 6 ft cable length allows easy connection via a 4 pin Phoenix plug to the lower connector (terminals 5, 6, 7, 8) on the back of the Catalyst Monitor.

The Dynalco host software is available as a free download from our website. Please call (954) 739-4300 if assistance is required in locating this file.

Following installation, you may click on the icon to open the application. This software will allow date selectable log values to be downloaded to an excel spread sheet on the PC.

Communication 

The unit also provides access to the internal registered values using the Modbus Protocol. The diagram below shows the recommended connections to the removable connectors on the back of the unit for either half-duplex or full-duplex (RS485).

Wiring is as follows:

PIN	Description
5	TD(A) **
6	TD(B) **
7	Jumper to PIN 5
8	Jumper to PIN 6

*** A 120 ohm termination resistor may need to be installed across pins 5 & 6.*

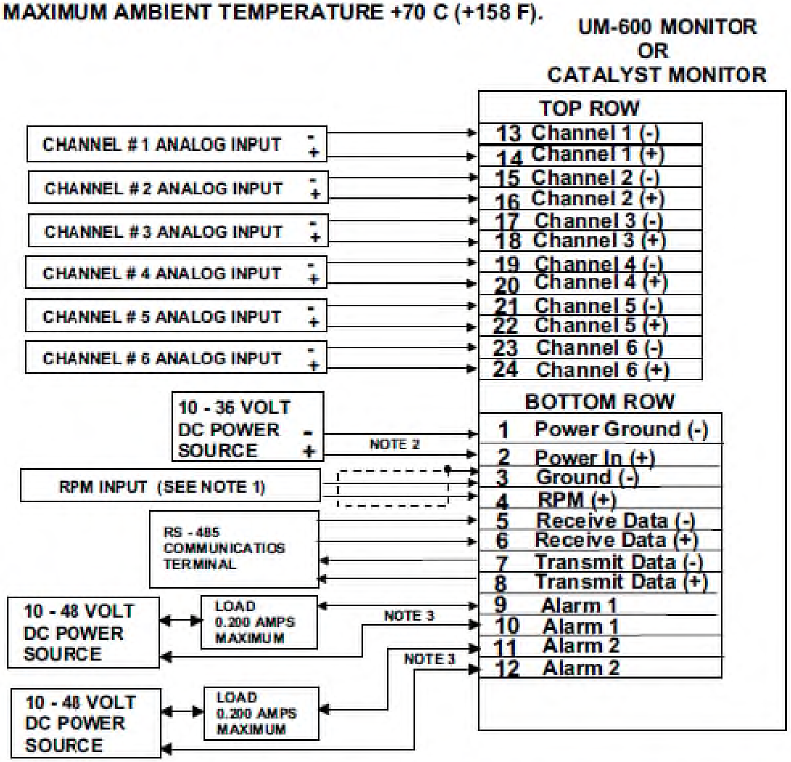
The Dynalco software delivers an Excel comma delineated file (.csv) with the log. This example is the Exhaust Inlet Temperature, measured every 15 minutes.

Date	EventID	Value
6/1/2012 9:56	0	1083
6/1/2012 9:41	0	80
5/31/2012 16:35	0	1079
5/31/2012 16:20	0	1079
5/31/2012 16:05	0	1079
5/31/2012 15:50	0	1079
5/31/2012 15:35	0	1079
5/31/2012 15:20	0	1079
5/31/2012 15:05	0	1079
5/31/2012 14:50	0	1079
5/31/2012 14:35	0	1079
5/31/2012 14:20	0	1079
5/31/2012 14:05	0	1079
5/31/2012 13:50	0	1079
5/31/2012 13:35	0	1079
5/31/2012 13:20	0	1081
5/31/2012 13:05	0	1081
5/31/2012 12:50	0	1082
5/31/2012 12:35	0	1074
5/31/2012 12:20	0	1079
5/31/2012 12:05	0	1079
5/31/2012 11:50	0	1077
5/31/2012 11:35	0	1076
5/31/2012 11:20	0	1079
5/31/2012 11:05	0	1079
5/31/2012 10:50	0	1077
5/31/2012 10:35	0	-4
5/30/2012 18:16	0	1189
5/30/2012 18:01	0	1187
5/30/2012 17:46	0	1189
5/30/2012 17:31	0	1190

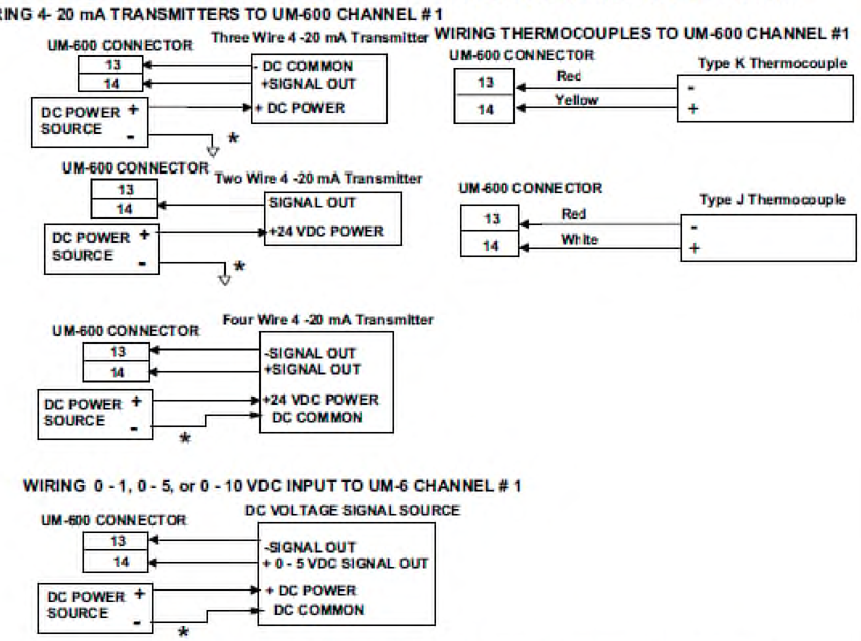
WARNING:

1. SUBSTITUTION OF COMPONENTS MAY IMPAIR DIVISION 2 CERTIFICATION.
2. WHEN USED IN DIVISION 2, DO NOT DISCONNECT UNLESS POWER HAS BEEN SWITCHED OFF OR THE AREA IS KNOWN TO BE NON-HAZARDOUS
3. MAXIMUM AMBIENT TEMPERATURE +70 C (+158 F).

REVISIONS			
LTR	DESCRIPTION	DATE	APPD



Wiring diagrams below are shown for Channel #1. Channels 2 thru 6 will be wired in a similar manner.



* 0 - 1, 0 - 5, 0 -10 VDC and 4/20 Milliamp Transmitters must be powered by a power supply which has the same common (-) as the power to the UM-600 Monitor.
4/20 Milliamp and 0 - 5 Volt Transmitters connected to the UM-600 Monitor must be approved for use in Class I, Division 2, Groups A, B, C, & D areas.

Any ungrounded thermocouple may be connected to the UM-600 Monitor as the thermocouple input circuit has been evaluated as non-incendive.

THE UM-600 AND CATALYST MONITOR ARE CSA APPROVED FOR USE IN CLASS I, DIVISION 2, GROUP A, B, C, & D LOCATIONS WHEN INSTALLED PER INSTRUCTIONS ON THIS DRAWING.

NOTES:
1. The M201, M202, M231, M233, M928, and M928-24 Magnetic Pickups have been approved to be connected to the RPM input. The pickup must be connected with shielded cable with the shield connected to terminal 3 as shown. As an alternative, a contact closure may be connected to the RPM input as a "RUN" signal.
2. The unit is powered by 10 - 36 Volt DC at 0.15 Amp max. DC power wiring must be run in CSA approved solid or flexible conduit.
3. The Alarm outputs may be connected to a load not to exceed 48 Volt DC and 0.2 Amps. Alarm output wiring must be run in CSA approved solid or flexible conduit.
4. The UM-600 and Catalyst Monitor are certified for mounting in a suitable enclosure. Suitability of the final combination is to be determined by CSA or the inspection authority having jurisdiction.

N:\PRODUCTS\Univ Meter\CSA\Interconnect.dsf

DO NOT SCALE THIS DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND TOLERANCES ARE:

FRACT.	DEC.	ANGLES
± 1/64	.XXX ± .005 .XX ± .01	± 1/2 DEGREE

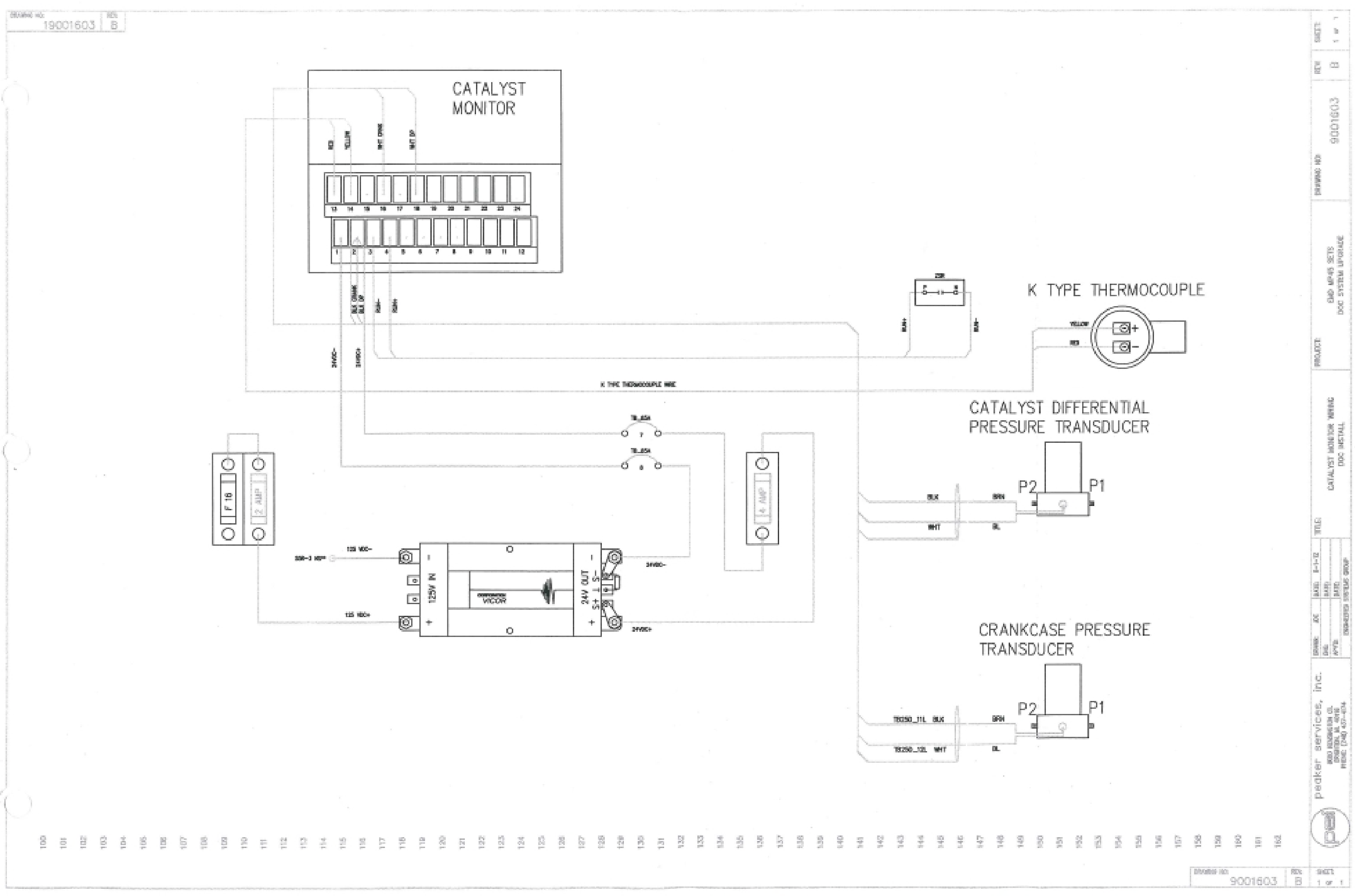
MATERIAL:

FINISH:

DYNALCO CONTROLS FT. LAUDERDALE, FL., USA

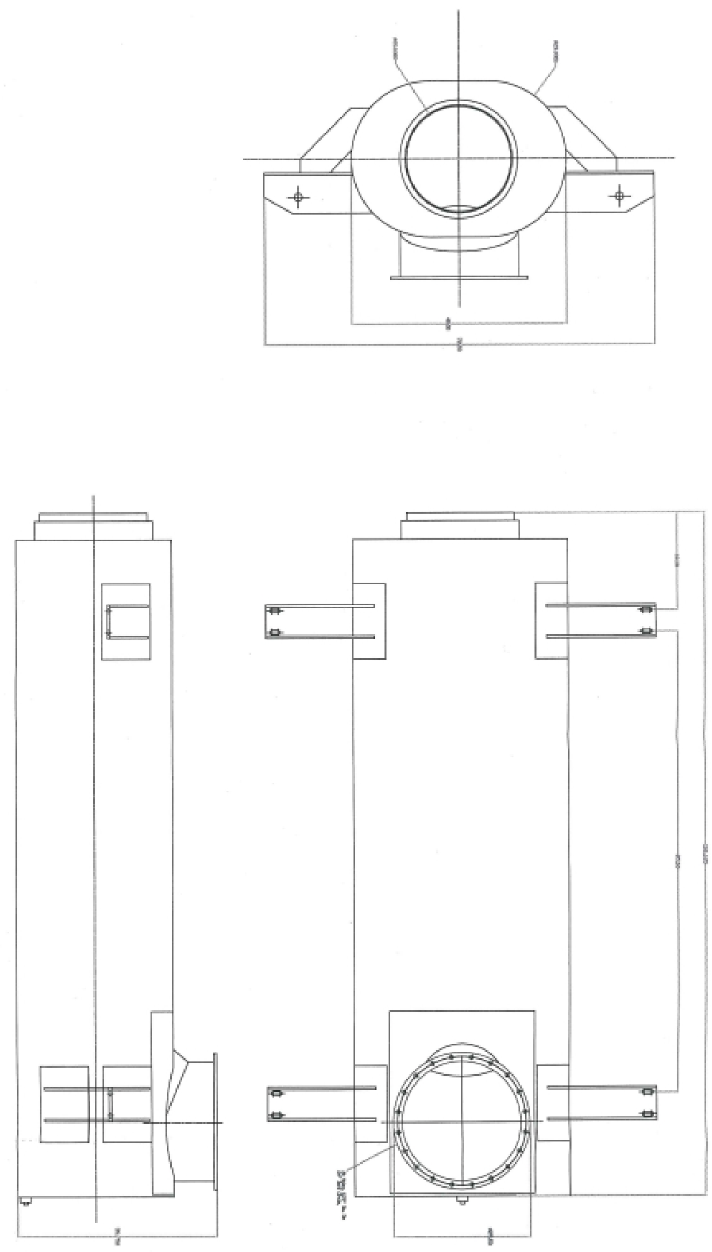
PRODUCT/PART: UM-600 CATALYST MONITOR	DRAWN: D. A. Weaver	APPROVED	DATE: 01/13/11
TITLE: INTERCONNECTION DRAWING CSA APPROVED UNITS			
SCALE	SIZE: A	DRAWING NUMBER: 80012970	PAGE 1 OF 1	REVISION: -

Appendix B - Drawings and Specifications



CATALYST MONITOR
K TYPE THERMOCOUPLE
K TYPE THERMOCOUPLE WIRE
CATALYST DIFFERENTIAL PRESSURE TRANSDUCER
CRANKCASE PRESSURE TRANSDUCER
P2
P1
F 16
2 AMP
4 AMP
125V IN
24V OUT
VICOR
DRAWING NO: 9001603
REV: B
SHEET: 1 OF 1
PROJECT: EMD MP45 SETS DOC SYSTEM UPGRADE
TITLE: CATALYST MONITOR WIRING DOC INSTALL
peaker services, inc.
ENGINEERED SYSTEMS GROUP

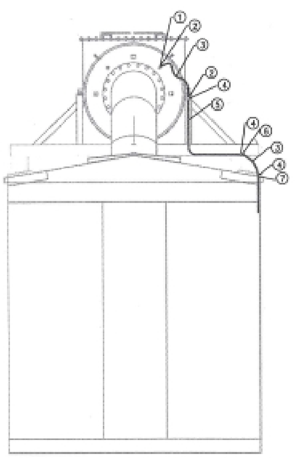
DRAWING NO: 9001606 | REV:



peaker services, inc.	DRAWN: JDC	DATE: 11-3-12	TITLE:	PROJECT:	DRAWING NO:	REV:	SHEET:
8085 KENSINGTON CT. BRIGHTON, MI 48116 PHONE: (248) 437-4174	ENG:	DATE:	6J2M-SSI-622 SILENCER DOC INSTALL	EMD MP45 SETS DOC SYSTEM UPGRADE	9001606		1 of 1
	APVD:	DATE:					
	ENGINEERED SYSTEMS GROUP						

DRAWING NO: 9001606 | REV: | SHEET: 1 of 1

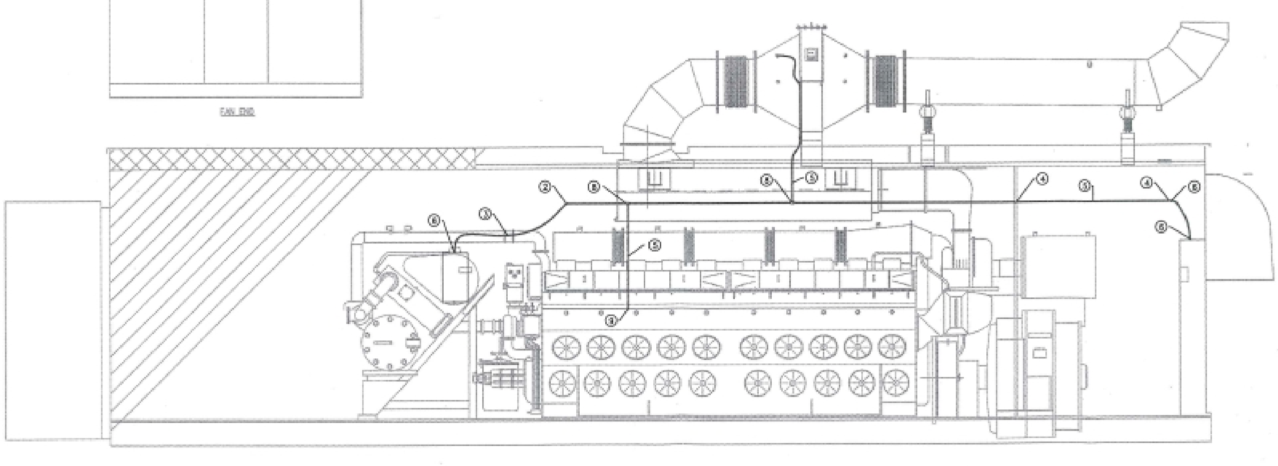
DRAWING NO. 9001607 REV.



FAN END

BILL OF MATERIALS

1. TEMPERATURE TRANSDUCER
2. ST-4550 LIQUIDTIGHT CONNECTOR
3. ½ LIQUID TIGHT FLEX CONDUIT
4. 51 – ½ RIGID COUPLING
5. GALV050 – ½ RIGID CONDUIT
6. ST-50 LIQUIDTIGHT CONNECTOR
7. ½ WASHER
8. LTM-50 ½ RIGID TEE W/GASKET AND COVER
9. LBM-50 ½ RIGID LB W/GASKET AND COVER



peaker services, inc.

DRAWN: JDC DATE: 11-3-12
ENGINEERED SYSTEMS GROUP

TITLE: CONDUIT RUN DTE SITES DOC INSTALL

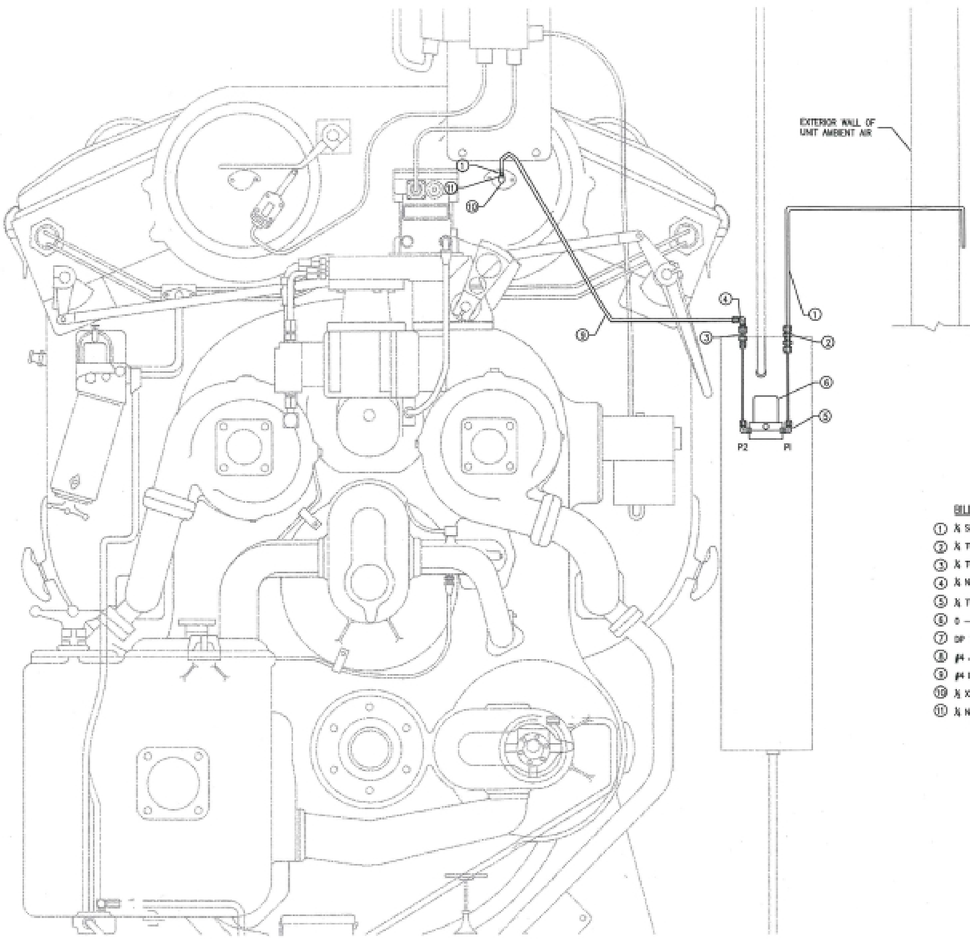
PROJECT: EMD MP45 SETS DOC SYSTEM UPGRADE

DRAWING NO: 9001607

REV: SHEET: 1 of 1

DRAWING NO. 9001607 REV. SHEET 1 of 1

DRAWING NO: 9001609 REV:



BILL OF MATERIALS

1. ¼ STAINLESS STEEL TUBE
2. ¼ TUBE X ¼ TUBE BULKHEAD
3. ¼ TUBE X ¼ FPT BULKHEAD
4. ¼ NPT X #4 JIC 90 ELL
5. ¼ TUBE X ¼ NPT 90 ELL
6. 0 – 10 DP TRANSDUCER
7. DP TRANSDUCER CABLE
8. #4 JIC HOSE END
9. #4 BRAIDED HOSE
10. ¼ X ¼ REDUCER
11. ¼ NPT X #4 JIC STR

peaker services, Inc.

DRAWN: JDC DATE: 10-1-12
ENG: DATE:
APPD: DATE:
ENGINEERED SYSTEMS GROUP

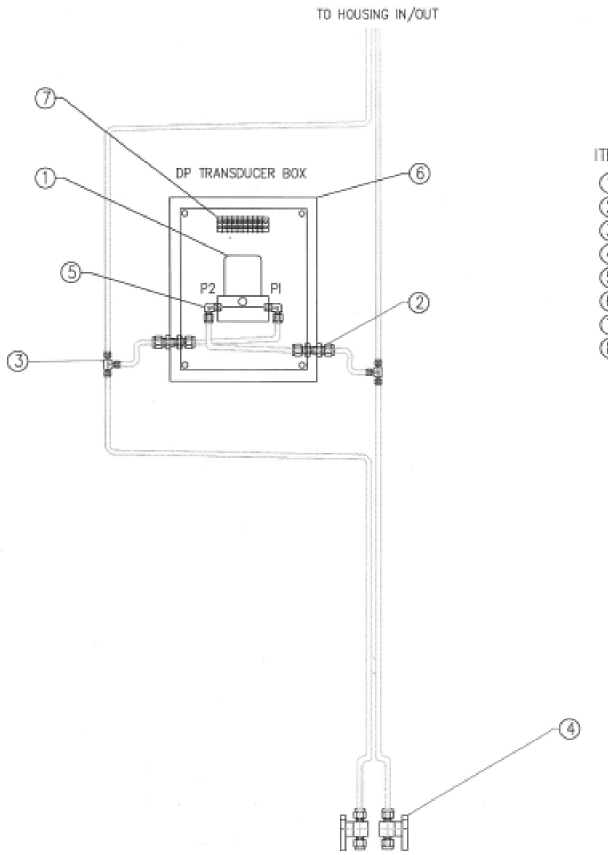
TITLE: DOC INSTALL CCV TRANSDUCER WITH TUBING LAYOUT DOC INSTALL

PROJECT: EMD MP45 SETS DOC SYSTEM UPGRADE

DRAWING NO: 9001609 REV: SHEET: 1 of 1

DRAWING NO: 9001609 REV: SHEET: 1 of 1

DRAWING NO. 9001610



BILL OF MATERIALS

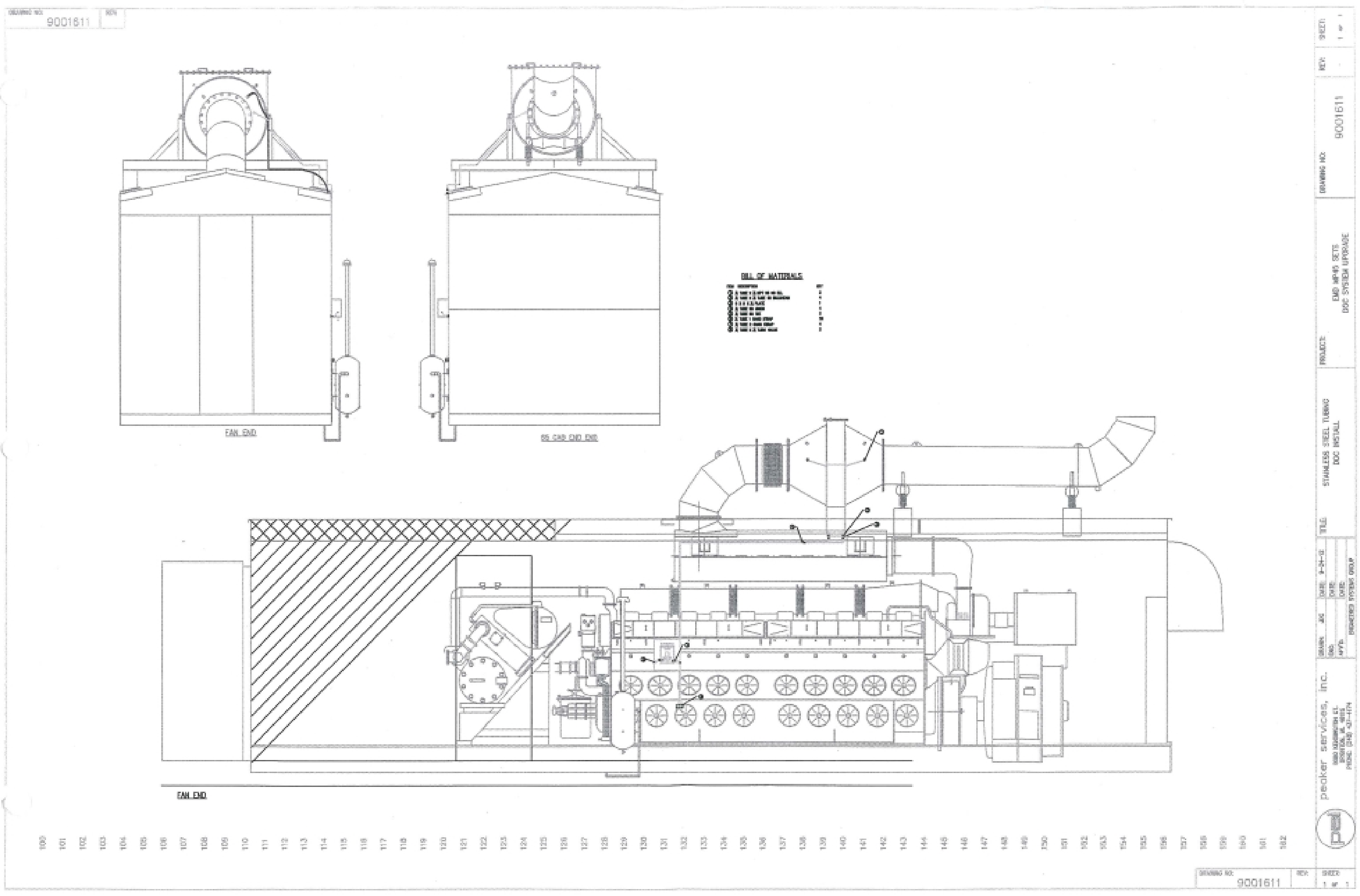
ITEM	DESCRIPTION	QTY
①	0-10 DIFFERENTIAL TRANSDUCER	1
②	¼ TUBE X ¼ TUBE SS BULKHEAD	2
③	¼ TUBE SS TEE	2
④	¼ TUBE X ¼ TURN VALVE	2
⑤	¼ TUBE X ⅛ NPT 90 ELL	2
⑥	10 X 8 X 6 HOFFMAN ENCLOSURE	1
⑦	10 POS TERMINAL BRD	1
⑧	10 X 8 X 6 HOFFMAN ENCLOSURE	1

peaker services, inc.

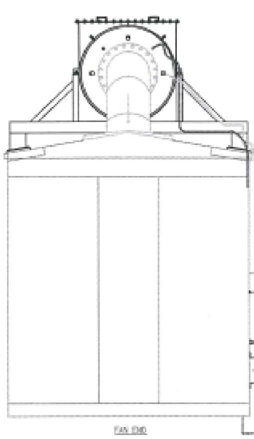
TITLE: DP BOX DOC INSTALL

PROJECT: EMP MP45 SETS DOC SYSTEM UPGRADE

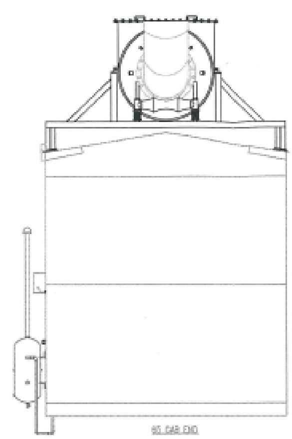
DRAWING NO. 9001610 SHEET 1 of 1


DRAWING NO:
9001611
REV:
FAN END
BILL OF MATERIALS
FAN END
STAINLESS STEEL TUBING
DOC INSTALL
PROJECT:
EMD MP45 SETS
DOC SYSTEM UPGRADE
DRAWING NO:
9001611
peaker services, inc.
SHEET:
1 OF 1

DRAWING NO. 9001613 REV.



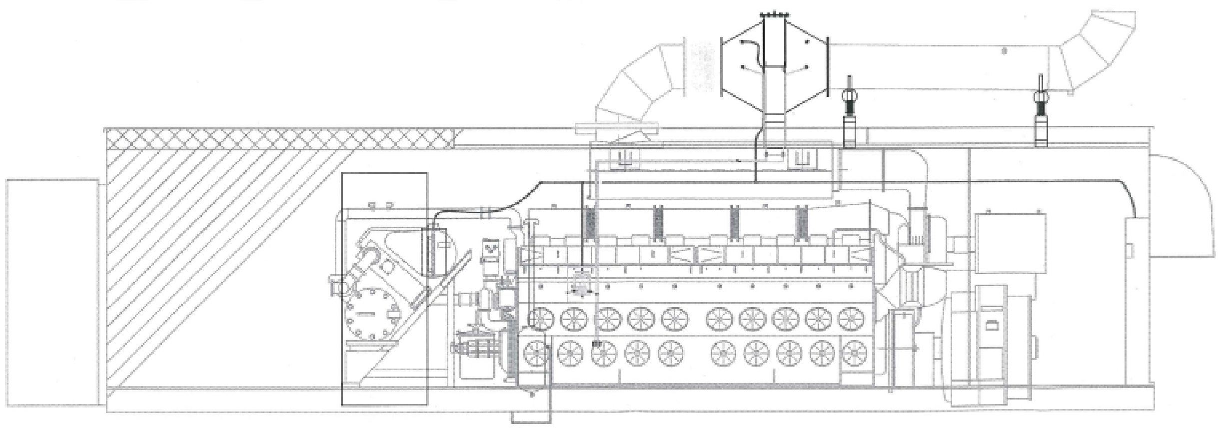
FAN END



65 CAB END

BILL OF MATERIALS

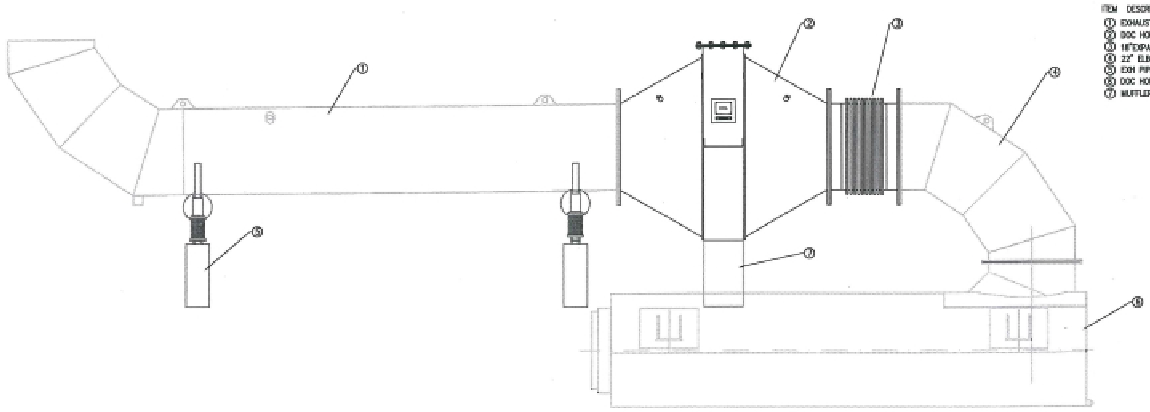
GREEN DWG# 431036 22" EXHAUST ELBOW
GREEN DWG# 431037 22" TAILPIPE
DWG# 431040 RAINGARD
BLUE DWG# 431041 HOUSING SUPPORT CRADLE
BLUE DWG# 431042 EXT PIPE SUPPORT BEAM
WHITE DWG# 251002 DOC HOUSING
CYAN DWG# 9001610 STAINLESS STEEL ROUTING
MAGENTA DWG# 9001701 AIR TANK INSTALL
DWG# 9001612 EXPANSION JOINT
RED DWG# 9001607 ELECTRICAL CONDUIT RUN



peaker services, inc. 8050 Kensington Ct. Brighton, MI 48116 Phone: (248) 437-4174	DRAWN: JJG DATE: 11-3-10 ENG: DATE: APPV'D: DATE: ENGINEERED SYSTEMS GROUP	TITLE: DOC SYSTEM INSTALLATION OVERVIEW WITH AIRBOX DRAIN	PROJECT: EMD MP45 SETS DOC SYSTEM UPGRADE	DRAWING NO: 9001613	REV:	SHEET: 1 of 1

DRAWING NO. 9001613 REV. SHEET 1 of 1

DRAWING NO. 9001614 REV.



BILL OF MATERIALS

ITEM	DESCRIPTION	QTY
1	EXHAUST PIPE 431037	1
2	DOC HOUSING 251002	1
3	18"EXPANSION JOINT 9001611	1
4	22" ELBOW 431036	1
5	EXH PIPE SUPPORT BEAM 431042	2
6	DOC HOUSING SUPPORT 431041	1
7	MUFFLER 9001606	1

peaker services, inc.

ENGINEERED SYSTEMS GROUP

TITLE: DOC OVERVIEW EXHAUST SYSTEM PIPING

PROJECT: EMD MP45 SETS DOC SYSTEM UPGRADE

DRAWING NO.: 9001614

SHEET: 1 of 1

DRAWING NO. 9001614 REV. SHEET: 1 of 1

DRAWING NO. 9001615 REV.

DESCRIPTION	QTY	PART NUMBER
65 CAB		
CAT MONITOR	1	CATALYST MONITOR
CAT MON LOG CABLE	1	PS-501018
14 ga X 1/2 EYE	1	
1/2 NYLOCK	1	
12S - 24 VICOR MODIFIED	1	VI-L54-CU
14ga x #10 eye	4	
ty wraps	100	
14ga X 1/4 EYE	3	
1/2 liquidtite strt	2	ST-50
1/2 liquidtite nut	2	BU50
1/2 rigid pipe HANGERS	3	601
1/2 liquid tite	7	ANAEFSTGRY1/2

DESCRIPTION	QTY	PART NUMBER
ENG COMPARTMENT		
1/2 rigid conduit	30	PIPE GALV050
RIGID TEES w/ caps	2	T1M
RIGID TEE COVER	2	MADISON LS-50
COVER GASKET	2	BRIDGEPORT SGN-61
1/2 rigid pipe HANGERS	3	601
1/2 LIQUID TITE 45 ELL	2	ST-4550
1/2 LIQUID TITE	8	ANAEFSTGRY1/2
1/2 RIGID COUPLING	1	51
1/2 LIQUIDTITE STRAIGHT	1	ST-50
3/4 ENGINE WASHER	2	
1/2 RIGID LB ELL w/ caps	2	L-61
RIGID TEE COVER	2	MADISON LS-50
COVER GASKET		BRIDGEPORT SGN-61

DESCRIPTION	QTY	PART NUMBER
25 CAB		
1/2 LIQUIDTITE	62	ANAEFSTGRY1/2
1/2 LIQUIDTITE STRAIGHT	1	ST-50
1/2 PLASTIC NUT	1	BU50
#4 BRAIDED HOSE	35	919-4
1/4 TUBE X 1/4 FM BULKHEAD	1	400-71-4
1/4 NPT X #4 JIC	1	4-4-FTX S
# 4 HOSE ENDS JIC	2	PEAK-2145-4001-004
1/2 CLOSE NIPPLES	1	51
1/2MPT X 1/4 FPT REDUCER	1	05002515BLTB
1/4 NPT X # 4 90 ELL JIC	1	4 CTXS
1/4" SS TUBE	52	SS-T4-S-035-10
1/4 X 1 GANG STRAP	1	11581-B
1/4 TUBE X 1/4 TUBE BULKHEAD	1	400-61
1/4 SS TUBE	25	SS-T4-S-035-10
1/4 X 2 GANG STRAP	2	12102-S / 12152-S
1/4 TUBE X 1/8 NPT 90 ELL	2	400-2-2
0 - 10 AST TRANSDUCER	1	ASTS100J0001OH4Y5000
AST CABLE	1	A10089
AST 90 CABLE	1	1536418
18ga X term	4	
1/4 X 1 HxHd	2	
1/4 int LW	2	

DESCRIPTION	QTY	PART NUMBER
DP BOX		
10 X 8 X 6 BOX	1	A100806CH
10 X 8 X 6 SUBPANEL	1	P1008
8 POS TB	1	538-8140
0 - 10 AST TRANSDUCER	1	ASTS100J00010H4Y5000
AST CABLE	1	A10089
1/4 TUBE X 1/8 NPT 90 ELL	2	400-2-2
1/4 TUBE X 1/4 TUBE BULKHEAD	2	400-61
18ga X # 8 EYE	4	
1/4 TUBE SS TEE	2	400-3
1/4 TUBE X 1/4 TURN VALVE	2	P1VH-4T-S316
1/4 X 2 GANG STRAP	4	12102-S / 12152-S
1/4 TUBE X CAP	0	P1VH-4T-S316
1/4 SS TUBE	40	SS-T4-S-035-10
1/2" X 4 NIPPLE	1	05040040GN
1/2 CHASE NIPPLE	2	INSIDE DP BOX

DESCRIPTION	QTY	PART NUMBER
AIR TANK		
20 GAL AIR TANK	1	1TZZ3
1 - 1/2" FLOAT	1	3610K46
2" VENT CAP	1	4815K15
1 1/2 BLK COUPLE FOR FLOAT	1	15015BLSTC
2" X 53" NIPPLE	1	20040BLWPTBE
1-1/2" X CLOSE	1	200CL40BLN
1-1/2" 90 ELL	1	20015BLT90
1-1/2" X 6 " NIPPLE	1	200600040BLN
1-1/2" x 3/4 red 90 ELL	1	20007515BLTR90
3/4 X 37 1/2 NIPPLE	1	07540BLWPTBE
3/4 90 ELL	2	07515BLT90
3/4 CLOSE NIPPLE	2	075CL40BLN
3/4 BLK UNION	1	07515BLTU
3/4 X 42" NIPPLE	1	07540BLWPTBE
3/4 BALL VALVE	1	075TFP600BV
3/4 black pipe	10	07540BLWPTE10
7/16 -14 X 3/4 BOLT / LW	4	FEET TO WELDED ROOF PLATE
3 x 12 x 1/2 PLATE	2	WELD PLATE FOR AIR BOX

DESCRIPTION	QTY	PART NUMBER
ROOF		
HOUSING	1	PS-251002
ELEMENT	1	20DOC 46x3.5x100 cpsi
RAINGARD	1	PS-431040
MUFFLER	1	532-MAB-222
22 SS ELL	1	PS-431036
22 SS EXT PIPE	1	PS-431037
22 X 18 BELLOWS	1	11-1F1-2218
HOUSING SUPPORT	1	PS-431041
EXT PIPE SUPPORT	2	PS-431042
SPRING CUSHION HANGER	2	0500081336 / FIG.178
ADJUSTABLE PIPE ROLLER	2	0500081203 / FIG.177D
1 1/4 X 3/4 BRASS RED	2	4429K472
3/4 X 1/2 BRASS RED	3	4429K414
TEMP TRANSDUCER	1	MTC-H-37522-U-012-V
1/2 LIQUIDTITE X 45 ELL	2	ST-4550
1/2 LIQUIDTITE	18	ANAEFSTGRY1/2
1/2 RIGID COUPLER	7	51
1/2 RIGID 90 SWEEP ELL	1	7513K31
1/2 LIQUIDTITE STRT	2	ST50
SS BULKHEAD PLATE	1	roof to mount 1/4 tube
1/4 TUBE X 1/4 TUBE BULKHEAD	2	400-61
1 1/4 BOLT - NUT	60	22 ansi flange
1 - 1/4 ZINC LW	60	22 ansi flange
22" ANSI GASKETS	3	48-CF-2200
HOUSING LID GASKET	1	HT-654-810001
1/4 TUBE X 1/2 MPT ELL	2	400-2-8
1 GANG SS CLAMP	8	11581-B
MUFFLER GASKET	1	HT-908-22912-C
1" SHIM PLATES	2	2 1/4 x 10 / 7" on ctr
1/4 SS TUBE	20	SS-T4-S-035-10
2 GANG SS STRAPS	3	12102-S / 12152-S
1/4 TUBE COUPLER	2	400-6
1/2 RIGID CONDUIT CLAMPS	3	601
5/8 X 3 ZINC BOLT - NUT- LW	4	housing to support
5/8 X 2 1/2 ZINC BOLT - NUT- LW	20	muffler to ell
1/2" X 4 NIPPLE	1	

peaker services, inc.

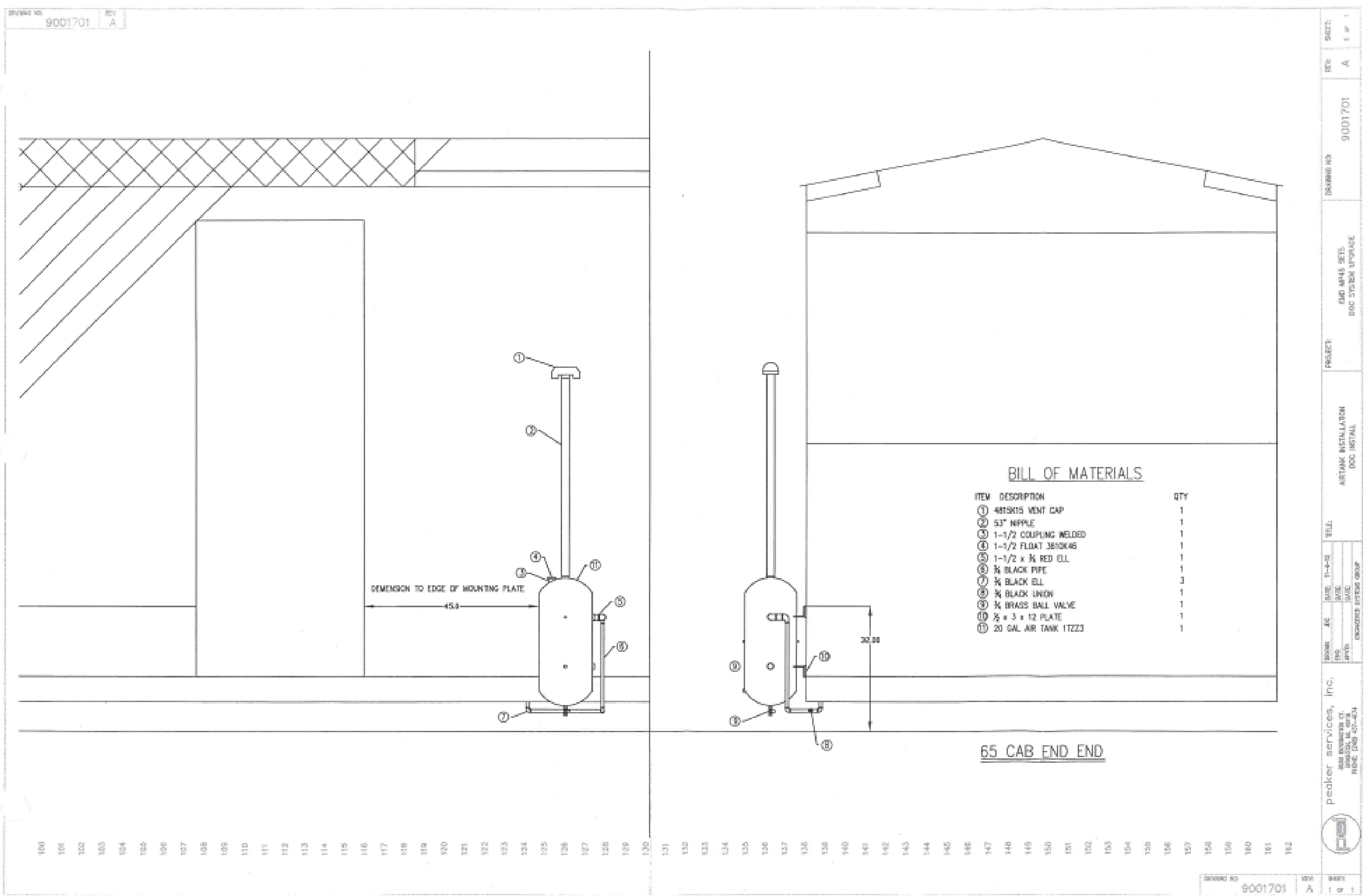
DRAWN: JDC DATE: 11-9-12

TITLE: DOC INSTALL BOM OTE SITES WITH AIRBOX DRAIN

PROJECT: EMD MP45 SETS DOC SYSTEM UPGRADE

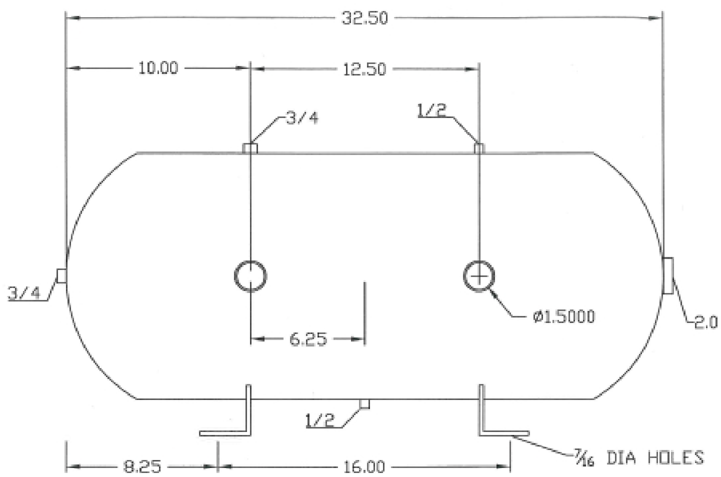
DRAWING NO: 9001615 REV: SHEET: 1 of 1

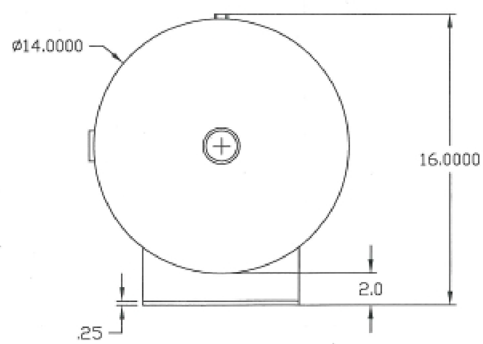
DRAWING NO. 9001615 REV. SHEET 1 of 1


DRAWING NO: 9001701
REV: A
DEMENSION TO EDGE OF MOUNTING PLATE
45.0
32.00
BILL OF MATERIALS
ITEM DESCRIPTION QTY
① 4815K15 VENT CAP 1
② 53" NIPPLE 1
③ 1-1/2 COUPLING WELDED 1
④ 1-1/2 FLOAT 3610K46 1
⑤ 1-1/2 x ¾ RED ELL 1
⑥ ¾ BLACK PIPE 1
⑦ ¾ BLACK ELL 3
⑧ ¾ BLACK UNION 1
⑨ ¾ BRASS BALL VALVE 1
⑩ ⅜ x 3 x 12 PLATE 1
⑪ 20 GAL AIR TANK 1TZZ3 1
65 CAB END END
peaker services, Inc.
TITLE: AIRTANK INSTALLATION DOC INSTALL
PROJECT: EMD MP45 SETS DOC SYSTEM UPGRADE
DRAWING NO: 9001701
REV: A
SHEET: 1 of 1

PART NO. 9001702 | REV.

* ASME CERTIFIED
* 175 PSI
* 20 GALLON CAPACITY

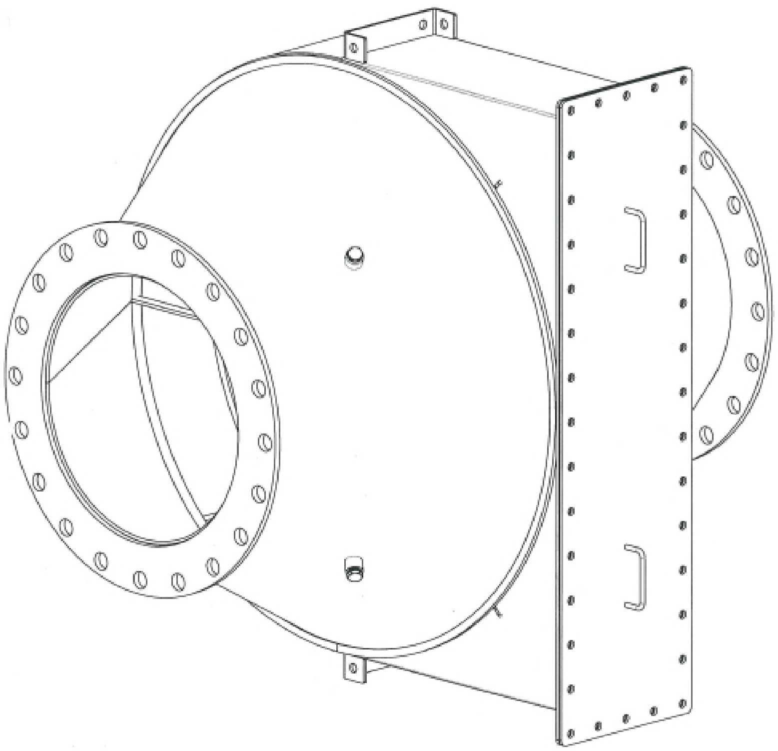




peaker services, inc. 8080 KENSINGTON CT. BRIGHTON, MI. 48116 PHONE: (248) 437-4174	TITLE: 1TZZ3 AIR BOX DRAIN TANK	
THIS DRAWING IS THE EXPLICIT PROPERTY OF PEAKER SERVICES INCORPORATED.	DRAWING NO. 9001702	REV:
DO NOT SCALE THIS DRAWING.	PROJECT: DOC SYSTEM UPGRADE EMD MP45 AIR BOX DRAIN SYSTEM	
TOLERANCES .X=± .XX=± .XXX=± ANG.=± — MAT'L:		
FINISH:	DRAWN: JC	DATE: 9-11-12
	ENG:	DATE:
SCALE: NONE	APV'D:	DATE:
ENGINEERED SYSTEMS GROUP	FILE NAME: 9001702	SHEET 1 OF 1

REV	REVISION	DATE	BY	APV'D

PART NO. 251002 REV. A



ITEM NO.	PUR	QTY	PART NUMBER	DESCRIPTION
1		2	431019	RETAINER TAB
2		2	431020	RETAINER CROSSBAR
3		2	431021	RETAINER VERTICAL BAR
4		8	431022	DIVIDER MOUNT TAB
5		2	431023	FIXED DIVIDER
6		1	431024	PANEL FLANGE
7		2	431025	DIVIDER
8		2	431026	LIFT BRACKET
9		2	431027	HANDLE
10		1	431028	ACCESS PLATE
11		2	431029	FLANGE
12		2	431030	CONICAL SECTION
13		2	431031	COUPLER RING
14		1	431032	SIDE COVER
15		2	431033	HOUSING COVER
16		1		GASKET
17	$	4	45525K565	PIPE COUPLER
18	$	4	9171K450	3/4" PIPE PLUG

peaker services, inc.
8080 KENSINGTON CT.
BRIGHTON, MI. 48116
PHONE: (248) 437-4174

TITLE: DOC HOUSING ASSEMBLY			
DRAWING NO. 251002		REV: A	
PROJECT: EMD MP45 SETS DOC SYSTEM UPGRADE			
TOLERANCES .X=± .XX=± .XXX=± ANG.=±	MAT'L: 304 STAINLESS		
	FINISH: NATURAL	DRAWN: BAB	DATE: 2-27-12
		ENG:	DATE:
	SCALE:	APV'D:	DATE:
ENGINEERED SYSTEMS GROUP		FILE NAME:	SHEET 1 OF 1

Appendix C - PSI Catalyst Operation and Maintenance Manual

peaker services, inc.
1-800-622-4224

ADVOCAT™ DOC Catalyst Element

Operating and Maintenance Manual

TABLE OF CONTENTS

1.0 GLOSSARY OF TERMS

CO – carbon monoxide

CO_2 – carbon dioxide

SCFH – standard cubic feet per hour

SCM – standard cubic meter

ppm – parts per million

ppmvd – parts per million volume dry

HRSG – Heat Recovery Steam Generator

Ambient temperature – temperature in the immediate or surrounding area

Monel nut – nut made of Monel metal that allows easy removal after being in service on a stainless steel bolt or stud.

CO module – A rectangular canister containing the catalyzed metal substrate.

T-Bar frame – structure on which the CO modules are mounted, forming the CO catalytic bed

O_2 – oxygen

UHC – unburned hydrocarbons

cpsi – cells per square inch

G's- acceleration of a mass of one pound resulting in one pound force

Support Spine – Support structure upon which the catalyst T-bar frame is supported

2.0 INTRODUCTION

The purpose of this document is to provide an overview of how a precious metal catalyst system functions and typical installation, operating, and maintenance guidelines to users of ADVOCAT™ DOC Oxidation Catalyst.

3.0 SYSTEM DESCRIPTIONS

A. Process Description

The combustion of hydrocarbon fuels typically produces small amounts of carbon monoxide. In the DOC ADVOCAT[TM] system, this residual carbon monoxide is converted into carbon dioxide by a precious metal catalyst, which promotes the desired chemical reaction to oxidize CO to CO_2, as follows:

$CO + ½ O_2 \rightarrow CO_2$

A catalyst is a substance that increases the rate of a chemical reaction but emerges from the process unchanged. By increasing the rate of reaction we are able to make thermodynamically favorable reactions occur in a time frame that is suitable to our needs. A catalyst increases the rate of reaction by participating in the intermediate steps of a reaction and providing an alternative reaction path (“mechanism”) for the reaction. This catalytic intervention results in a lowering of the overall activation energy requirements, thus permitting a reduction in the temperature at which the process can proceed favorably. The term catalyst, as typically used in this document, refers to the sum product of components that make the reactions occur. In reality the catalyst consists of a substrate, washcoat (or support), and precious metal.

The surface of a catalyst is comprised of numerous “active sites” which are simply sites onto which a molecule in the surrounding air may attach. This attaching affects the bond structure of the attached molecule in such a fashion as to make it much easier for bonds to be broken. The act of attaching may, by itself, be responsible for the initial bond breaking. Certainly the act of attaching significantly alters the bond structure. Oxygen from the air stream is initially adsorbed onto the surface of the catalyst. The surface interaction of the catalyst with the oxygen greatly distorts the oxygen bond. In its distorted state, the oxygen is much more strongly oxidizing toward carbon monoxide.

To promote a high rate of gas contact with the catalyst surface while maintaining low system pressure drop, ACS uses a monolithic honeycomb structure, which consists of many parallel cells through which the exhaust gas passes. The high cell density per square inch of honeycomb, combined with its high surface area, assures a very efficient rate of gas contact with the catalyst surface and, therefore, a high conversion rate of CO to CO_2.

B. *Factors Affecting Catalyst Performance*

Temperature is a significant factor affecting conversion. The higher the temperature the more favorable are conditions for the oxidation reaction to occur. Another significant factor that affects conversion is the amount of gas that the catalyst is forced to process in a given time. Higher conversion will be achieved when the catalyst is forced to process a smaller volume of gas in a unit time. In the catalysis industry, the concept of space velocity is used to quantify this idea. Space velocity is defined as:

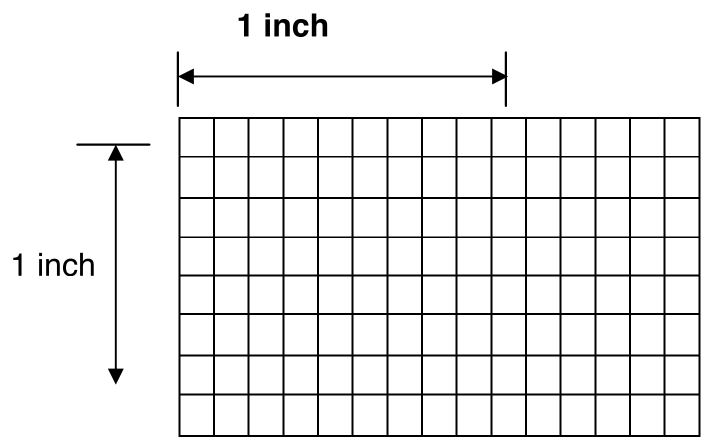
$$\text{Space Velocity} = \frac{\text{Gas volumetric flow rate/hr}}{\text{Catalyst volume in service}}$$

The gas volumetric flow rate is usually expressed in units such that when divided by the catalyst volume, the unit of space velocity is reciprocal hours (1/hr). One can think of space velocity as expressing the catalyst volume equivalents of gas that a catalyst processes in one hour. For example, a space velocity of 50,000/hr indicates that the catalyst is processing 50,000 times its own volume of gas every hour. Lower space velocity is associated with higher conversions.

Another important factor that affects overall conversion is catalyst support geometry. The support structure is almost always metal or ceramic and is constructed in such a manner as to give a high global surface area.

Honeycomb geometries are specified by their “cell count”. Cell count is defined as the number of individual cells or cell equivalents contained within a given cross-sectional area (typically one square inch). If one describes a honeycomb structure as “100 cell” this means that the monolith in question has 100 individual cells contained within an area of one square inch of the catalyst face (this also implies that there are ten cells per linear inch if the honeycomb is square). The following illustration visually presents the concept of cell count.

Illustration A



Cell count is the actual number of cells per unit area. Cell count may also be referred to as cell per square inch (cpsi).

C. Destruction Efficiency (percent conversion)

The effectiveness of a catalyst is stated by percent conversion. The percent conversion is determined by the equation:

$$\% \text{ Conversion} = \left(1 - \frac{\text{Catalyst outlet concentration}}{\text{Catalyst inlet concentration}}\right) \times 100$$

D. Equipment Description

The ADVOCAT™ catalyst is supported by a high temperature stainless steel multi-cellular monolithic structure. The structure is coated with a high surface area alumina layer designed to distribute and disperse the catalytic component. The catalytic component is platinum.

The special stainless steel foil is corrugated and placed upon itself to make a honeycomb core. The structure has 100 cells per square inch and has web thickness of about 0.002 inches. The "honeycomb" has a high global surface area and low porosity, thus giving excellent contacting of catalyst with the exhaust stream with minimum resistance to flow (i.e. low pressure drop).

The particles of Platinum are very small of the order of 20 to 50 angstroms (one angstrom is 0.00000001 centimeters). The small dimensions give rise to high metal surface area. This surface area is stabilized by supporting the Platinum crystallites on a high surface area alumina based coating, which in turn adheres to the walls of the stainless steel structure. This core and enclosure is called a “module”.

E. Safety Considerations

The converter is designed to oxidize carbon monoxide in the gas turbine exhaust. This occurs as the exhaust passes over the precious metal-coated catalyst at elevated temperatures. These high temperatures make it mandatory that personnel be protected against injury. Do not attempt to work around the converter modules if temperatures exceed 110°F.

<u>System Precautions</u>

Always use caution in working around the converter during a shutdown period. If the converter shuts down because of a high temperature or any other reason, pay particular attention to hot surfaces and make sure there is adequate area ventilation. This is especially important when inspecting, removing, or installing the converter. If necessary, use a ventilation fan to keep fresh air flowing in the converter during inspection, removal, or installation.

Any time the converter is not in operation because of the need to perform maintenance work take the appropriate equipment lockout measures.

Use proper personnel protection at all times when installing or removing catalyst modules. Read the recommendations below before starting any procedures:

A. Provide adequate ventilation

B. Wear leather gloves when handling catalyst modules. Metal edges of the modules are sharp and can cut and bruise.

C. Wear safety glasses with side shields or goggles when installing or removing modules from the frame. Protruding threading studs on the frames may often be at eye level.

D. Wear safety shoes and a hard hat.

E. Wear appropriate fall protection equipment as required during module loading.

F. Modules should be lifted within a lifting fixture during loading.

G. Precautions should be taken to prevent injury from falling objects while loading modules (nuts, clips, modules, tools).

H. Follow OSHA standards for confined space entry and fall protection.

Review the operation of the converter with the plant safety officer before starting the unit. Any suggestions and additions should be added to those instructions.

All those involved in the operation of the converter should read and understand the complete operating instructions before starting the system. Safety meetings of all those involved with the converter should be held periodically in conjunction with housekeeping reviews.

4.0 OPERATING CONDITION

Duct Interface	INSIDE LINER
CIRCUMFERENCE	48”

See Appendix E for operating conditions for all load cases.

Operating Requirements

Over-temperature Protection

The converter can operate up to a maximum temperature of 1100°F, although it is designed for a peak continuous operating temperature of 1050°F. In the event of an engine malfunction, it is possible for the exhaust gas temperatures to exceed 1100°F. For thi s reason, over-temperature protection must be provided. This over-temperature protection should consist of thermocouples upstream and downstream of the CO converter, and a visible annunciation with audible alarm. The alarm should sound at 1075℉, and the reason for th e over-temperature condition should be determined and corrected. If the turbine exhaust temperature reaches 1100℉, the engine should shutd own and corrective action taken.

Differential Pressure Protection

A differential pressure transmitter should be installed to determine the pressure drop across the converter. The maximum expected pressure drop at the maximum flow and lowest temperature is approximately 1.09 inches w.c. If the pressure drop exceeds 2.0 an alarm should sound, and the reason for the condition should be determined and corrected.

Engine Lubricating Oil

Catalyst durability is significantly affected by the type and consumption rate of turbine lubricating oil. Low ash, phosphorous-free oils are recommended for prolonged catalyst durability.

Housekeeping

Keep the area free from any hazards that would prevent easy movement around the converter or easy access into the casing interior. No flammable or otherwise hazardous materials should be stored in the immediate vicinity of the converter.

Catalyst Washing

See Appendix C for catalyst washing requirements.

5.0 INSTALLATION

No Special Tools are required for catalyst installation.

B. CO Catalyst Converter Module

Before installing the CO catalytic converter modules, take these precautionary steps:

1. Thoroughly clean the upstream ducting and liner, removing all dirt, oil, grease, rags, etc.

2. Operate the engine before installation of the CO converter to ensure that all debris has been blown out of the system.

3. Adequately sized planks and/or scaffold support equipment must be placed across the length of the catalyst frame allowing for a safe and accessible work area during the catalyst installation

4. Seat module into frame.

5. Check to ensure that the catalyst is seated properly and all sealing components are properly aligned. If the catalyst is not seated properly, gas will bypass the catalyst.

6. Clean duct areas after all modules are installed and prior to engine start-up.

6.0 TESTING

There are usually three types of testing done on CO catalytic converters. One is acceptable testing by the local air quality authority or Federal EPA. The second is testing of the internal catalyst core samples to determine an "aging curve" to give an idea of catalyst replacement intervals. The third is "before and after" testing to determine the catalyst efficiency, pressure drop, and face velocity profile.

7.0 Operating Instructions

A. PRE-STARTUP INSPECTION

Precautions should be taken when starting up the system for the first time. The following items should be checked prior to system start-up:

a. Inspect the ducting up stream of the catalyst to be sure there are no loose places in the duct liner that will allow loose insulation to escape.

b. Be sure no loose object or trash is present in the duct upstream of the catalyst.

c. Inspect the catalyst housing, duct liner and expansion joints to be sure they are installed correctly.

d. Inspect catalyst support frames for any damage during field erection.

The DOC catalyst is designed to operate, to the largest degree possible, in the same thermal environment as the engine. However, when gas is admitted to the system for the first time, it is necessary to take extra precautions to reduce thermal shock and possible distortion.

As with any piece of fired equipment, it is desirable to hold to minimum of thermal shock, temperature spikes, excursions and unnecessary thermal cycling.

The DOC catalyst should not be exposed to direct flame at any time.

B. INITIAL ENGINE FIRING

Care in admitting exhaust gas to the catalytic converter for the first time is important. The ramp up of temperatures in the system is more difficult to control.

The objective of the initial start-up procedure is to have the support frame assembly heat up as a unit as uniformly as possible. The support structure will grow in the vertical and horizontal directions from a cold to a hot operating condition. The changes in temperature, exercise the seal system as well as other parts of the system. At the time of initial engine firing, the following steps are recommended.

1. Inspect the oil seals and determine that the engine is operating properly and there are no potential oil leaks.

2. Start the engine and attain synchronous idle conditions.

3. Maintain these conditions until the catalyst and support frame are uniformly heated.

4. Increase the engine power slowly, keeping the catalyst support frame uniformly heated with no hot spots, through the time when the desired maximum output is achieved.

After the initial start-up has been completed the catalyst modules and gaskets should be installed and the system re-started as recommended above.

C. POST START-UP INSPECTION

After the initial start-up has occurred and the engine has been run for some period of time, it will be necessary to enter the duct and inspect the support frame, seals and structure. The following items will be checked:

1. Look for oil fouling or insulation on the catalyst frame structure.

2. Check the support structure for cracks or broken parts.

APPENDIX A "MSDS"

MATERIAL SAFETY DATA SHEET DATE: Jan. 1998	
Product Name:	**STAINLESS STEEL CO CATALYST**
SECTION I	
Distributor's Name:	Peaker Services, Inc. 8080 Kensington Ct Brighton MI., 48116 Telephone: 800-622-4224
Chemical Name and Synonyms: CO Catalyst Formula: N/A	

SECTION II HAZARDOUS INGREDIENTS						
					TLV (Units)	
PRINCIPAL HAZARDOUS COMPONENT (S)	CAS #	% by WEIGHT	ORAL LD_{50}	DERMAL LD_{50}	ACGIH	OSHA
CHEMICAL NAME Platinum (Pt) COMMON NAME Platinum	7440-06-4		No Data	No Data	0.002 mg/m^3	0.002 mg/m^3
CHEMICAL NAME Aluminum Oxide (Al2O3) COMMON NAME Alumina	1344-28-1		No Data	No Data	10 mg/m^3	5 mg/m^3
CHEMICAL NAME Stainless Steel Monolith COMMON NAME Stainless Steel Monolith	No info.		No Data	No Data	None	None
CHEMICAL NAME COMMON NAME						
CHEMICAL NAME COMMON NAME						
CHEMICAL NAME COMMON NAME						
CHEMICAL NAME COMMON NAME						

* No animal mortalities during course of 14-day study.

This product is non-hazardous according to the definitions for "health hazard" and "physical hazard" provided in the OSHA Hazard Communication Law (29 CFR part 1910).

SECTION III PHYSICAL DATA

BOILING POINT (F)	N/A	SPECIFIC GRAVITY (H_20=1)	N/A
VAPOR PRESSURE (mmHg)	N/A	PERCENT VOLATILE BY VOLUME (%)	N/A
VAPOR DENSITY (AIR=1)	N/A	PH	N/A
SOLUBILITY IN WATER	insoluble	OTHER packing density	N/A
APPEARANCE AND ODOR	Black coating with no distinct odor.		

While this information and recommendations set forth herein are believed to be accurate as of the date hereof, PEAKER SERVICES INC. MAKES NO WARRANTY WITH RESPECT HERETO AND DISCLAIMS ALL LIABILITY FROM RELIANCE THEREON.

SECTION IV FIRE AND EXPLOSION HAZARD DATA	
Flash Point (Method Used)	N/A
Extinguishing Media	As appropriate for combustibles in area
Special Fire Fighting Procedures	None
Unusual Fire and Explosion Hazards	None

SECTION V HEALTH HAZARD DATA

EFFECT OF OVEREXPOSURE

A. ACUTE

1. INGESTION

The product is non-toxic through ingestion

2. INHALATION

N/A

3. DERMAL EXPOSURE

a. TOXIC

Non-Toxic

b. IRRITATION

This product is not a skin irritant.

c. SENSITIZATION

None

4. EYE IRRITATION

This product is not an eye irritant

B. SUBCHRONIC, CHRONIC, OTHER

The effects of long-term, low-level exposures to this product have not been determined. Safe handling of this material on a long-term basis should emphasize the avoidance of all effects from repetitive acute exposures.

FIRST AID
A. EYE Flush with plenty of water for 20-30 minutes. If irritation, tears, and redness persists seek medical attention.
B. SKIN Wash with soap and water.
C. INGESTION This product is not expected to be an ingestion hazard. No human or animal defects have been documented.
D. INHALATION N/A

SECTION VI REACTIVITY DATA			
STABILITY	STABLE	X	CONDITIONS TO AVOID NONE
	UNSTABLE		
INCOMPATABILITY: (Materials to Avoid)	Keep away from extreme heat and open flame.		
HAZARDOUS ECOMPOSITION PRODUCTS	None		

SECTION VII SPILL OR LEAK PROCEDURES	
REPORTABLE QUANTITIES (RQ) IN LBS OF EPA HAZARDOUS SUBSTANCES IN PRODUCT	1.__N/A 2.______ 3.______
STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED	Sweep up and save for reclaiming precious metals.
WASTE DISPOSAL METHOD	Save material and recycle for precious metal value.

<table>
<tr><th colspan="4">SECTION VIII HANDLING & STORAGE</th></tr>
<tr><td colspan="2">PROTECTIVE GLOVES
Rubber gloves recommended</td><td colspan="2">EYE PROTECTION
Safety glasses or goggles recommended</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">OTHER PROTECTIVE CLOTHING
None</td></tr>
<tr><td colspan="4">RESPIRATORY PROTECTION
None</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="2">VENTILATION</td><td>Local exhaust</td><td>None</td><td rowspan="2">OTHER:</td></tr>
<tr><td>MECHANICAL (general)</td><td>None</td></tr>
<tr><td colspan="4">STORAGE & HANDLING
Store at room temperature and wear gloves when handling.
Exercise caution in the storage and handling of all chemical substances</td></tr>
<tr><td colspan="4">OTHER PREACAUTIONS
Wash thoroughly after handling.</td></tr>
</table>

APPENDIX C "Catalyst Maintenance/Washing Procedure"

ADVOCAT™ DOC catalyst is a platinum metal based catalyst and should not require regular catalyst maintenance if the engine exhaust gas remains clean of potential blocking (insulation) and/or masking agents (dirt, dust, iron oxides, excessive engine lubricate oil, etc.). A build-up of blocking material (indicated by an increase in pressure drop across the catalyst or slight build-up of masking agents on the catalyst surface indicated by a reduction in CO destruction) can be removed with a light demineralized water spray across the catalyst. This washing can be performed while the catalyst remains installed. If excessive masking agents are present on the catalyst, removal and chemical washing of individual modules would be required to regain original performance. Catalyst test coupon evaluation and catalyst washing services are available.

Trouble Shooting Matrix:

Problem Description	Potential Cause	Recommended Action
Reduction in CO conversion.	Potential masking of catalyst.	Remove test coupon and send for performance evaluation.
Reduction in CO conversion.	Change in Operating Conditions	Examine periodic performance history to determine if there is a change in operating conditions. Test catalyst inlet and outlet CO conditions for comparison.
Increase in pressure drop across catalyst bed.	Potential masking or blocking of catalyst.	Inspect catalyst for cell blockage. Remove material or blockage with light DM water spray.

Pressure drop and CO destruction measurements, across the catalyst, should be taken on a regular basis by Plant operators to monitor the catalyst performance and need for maintenance.

Chemical washing/regenerating Procedure:

Use only demineralized water for making the different solutions and rinse steps. Take all the safety precautions needed.

Equipment and materials needed

1. There will be four (4) tanks needed for this process.
2. The first tank will contain a solution of 10% KOH (Potassium Hydroxide), tank 1. (Make enough solution and have enough demineralized water in every step to completely immerse all the units.)
3. The second tank will contain Demineralized water, tank 2.
4. The third tank will contain a solution of 10% HOAc (Glacial Acetic Acid), tank 3.
5. The fourth tank will contain Demineralized water, tank 4.

Procedure

1. The first set of DOC catalysts will be completely immersed in the first tank, tank 1, (10% KOH) and the units will be washed/regenerated for 20 minutes.
2. Take the units out of the first tank and rinse them with Demineralized water. Gently shake them to remove any excess liquid stored in the units. If you have a high volume low pressure blower, gently blow them to get the excess water off. **Do Not** use any high-pressure air to blow the units since this will cause the washcoat to come off. Place the units in tank 2 for 10 minutes.
3. Take the units out of tank 2 and follow the same procedure to remove the excess liquid stored in the cells.
4. Place the units in tank 3 (10% HOAc) and leave them there for 20 minutes. Make sure the liquid level is always on top of the units.
5. Take the units out of tank 3 and follow the same liquid removal procedure.
6. Place the units in tank 4, and leave them there for 10 minutes.
7. Follow the same procedure to remove any excess liquid.
8. Dry the units – air cool dry or in a furnace if available (300°F).
9. Neutralize the solutions left and dispose properly.
10. Follow the same procedure, beginning at step #1 to wash the next sets of units.

Since the solutions you are using are highly caustic and acidic, make sure the safety equipment needed (gloves, goggles, aprons, respirators, and any other piece of equipment you might need) are used throughout the process.

After these modules are taken through this process and they are dry, they are ready to be re-installed. When handling the DOC units, pay extra attention that the cells do not get hit in any way, as this will plug them.

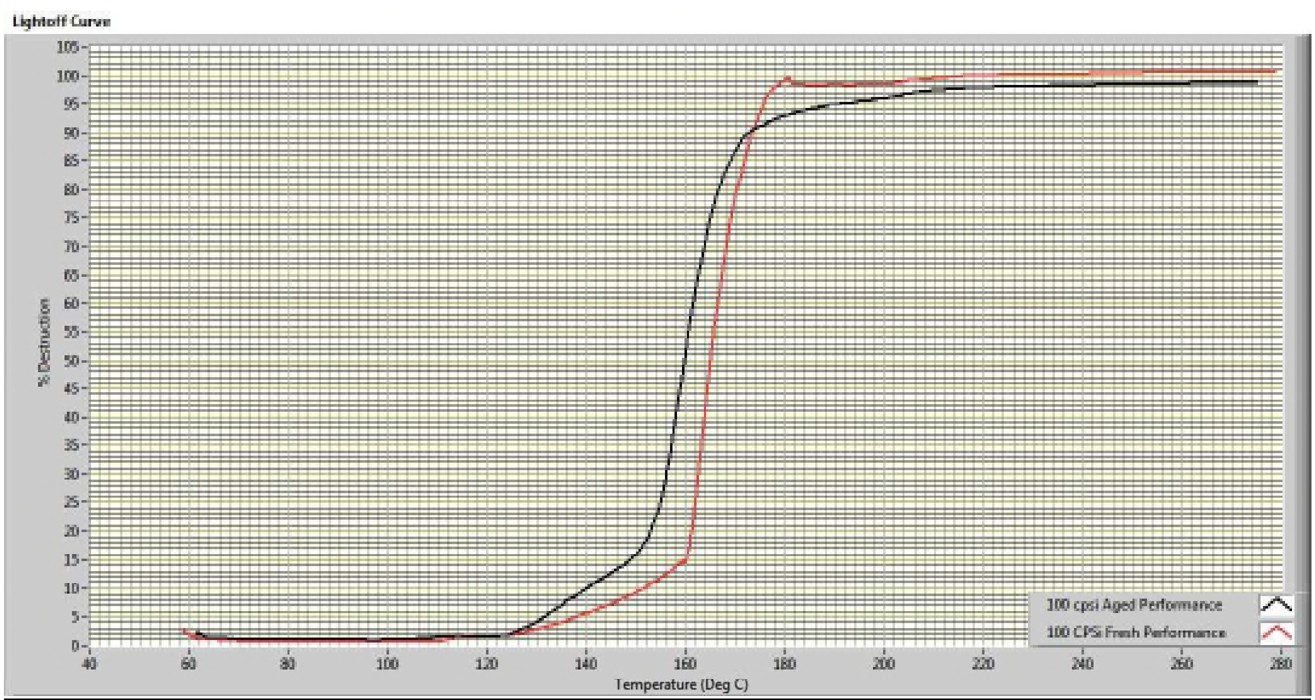
Please note that the procedures above are for blocking and masking agents on the catalyst, as noted in the warranty there are poisoning agents that cannot be washed from the catalyst. The presence of these poisoning agents in the exhaust gas stream will void the catalyst warranty.

APPENDIX E “Operating Conditions”

Parameter	Units	Case 1	Case 2
Fuel Type		ULSD	ULSD
Temp at Catalyst	°F	742	670
Exhaust Flow	ACFM	22,000	22,000
CO Destruction Required	%	70	70
Gas Hourly Space Velocity		161,429	172,860
Expected Pressure Drop	" w.c.	1.38	1.38
Guaranteed Pressure Drop	" w.c.	1.63	1.63

APPENDIX F “Performance Test Curves”

-CO Oxidation Efficiency (%):



Appendix D - GM Engine Operating Manual

Wilmot Sub.
E - 910698
Reg. 52718

OPERATING MANUAL

Permit Callaway Power

MU-20E POWER PLANTS

for

PEAKING, RESERVE, AND BASE LOAD OPERATION

Placid
E021694
22498

Port Huron
E021693
22428

St. Clair
E-021692
22429

Tanners Creek
E021691
22427

Turbo Channel
4E-82010

2nd Edition

April, 1968

Service Department

Electro-Motive Division
La Grange, Illinois

GM
MARK OF EXCELLENCE

13787

PRINTED IN U.S.A.

INTRODUCTION

This manual has been prepared to serve as a guide to personnel engaged in the operation of the General Motors Corporation, Electro-Motive Division MU type power plant. Additional information on application, installation, and maintenance may be found in the Maintenance Instructions, the 645E4 Engine Manual, and the Application and Installation Data book. For specific equipment, various manufacturer's pamphlets are helpful.

The information contained in this manual covers the typical MU type installation and common optional equipment. The function of the equipment and related accessories as described in this manual is of necessity based on a general type of installation and the descriptions and explanations will not be completely applicable to specific MU type power plants. However, the information will aid in providing an understanding of any installation and will be useful to operating personnel. The wiring diagrams and assembly drawings for specific plants take precedence over information presented in this general manual.

The contents of this manual are divided into eight sections and an appendix as follows:

Section 1 - GENERAL DESCRIPTION
Briefly describes the power plant and its operation.

Section 2 - MP TYPE GENERATING UNIT
Briefly describes equipment in the generating unit.

Section 3 - OUTDOOR SWITCHGEAR STATION
Briefly describes equipment in the switchgear station.

Section 4 - INSTALLATION AND PRE-SERVICE CHECK
Briefly describes necessary procedures before first operation.

Section 5 - AUTOMATIC OPERATING SEQUENCE
Gives the operating sequence for control equipment in various modes of operation.

Section 6 - MANUAL OPERATION
Gives operating procedures in the manual mode.

Section 7 - DESCRIPTION OF ELECTRICAL DEVICES
Describes functions of relays, meters, and control devices.

Section 8 - ANNUNCIATOR OPERATION AND TROUBLE SHOOTING
Describes the annunciator alarm system and trouble shooting procedures.

Appendix - Contains pertinent information in tabular form.

A block of page numbers is allocated to each section, Section 1 starting with page 101, Section 2 with 201 and the others following in this manner. Figures are identified by section and sequence. For example: Fig. 2-3 is the third figure in Section 2.

To obtain the most benefit from this manual, it is recommended that the sections be read in the sequence in which they appear.

TABLE OF CONTENTS

Page

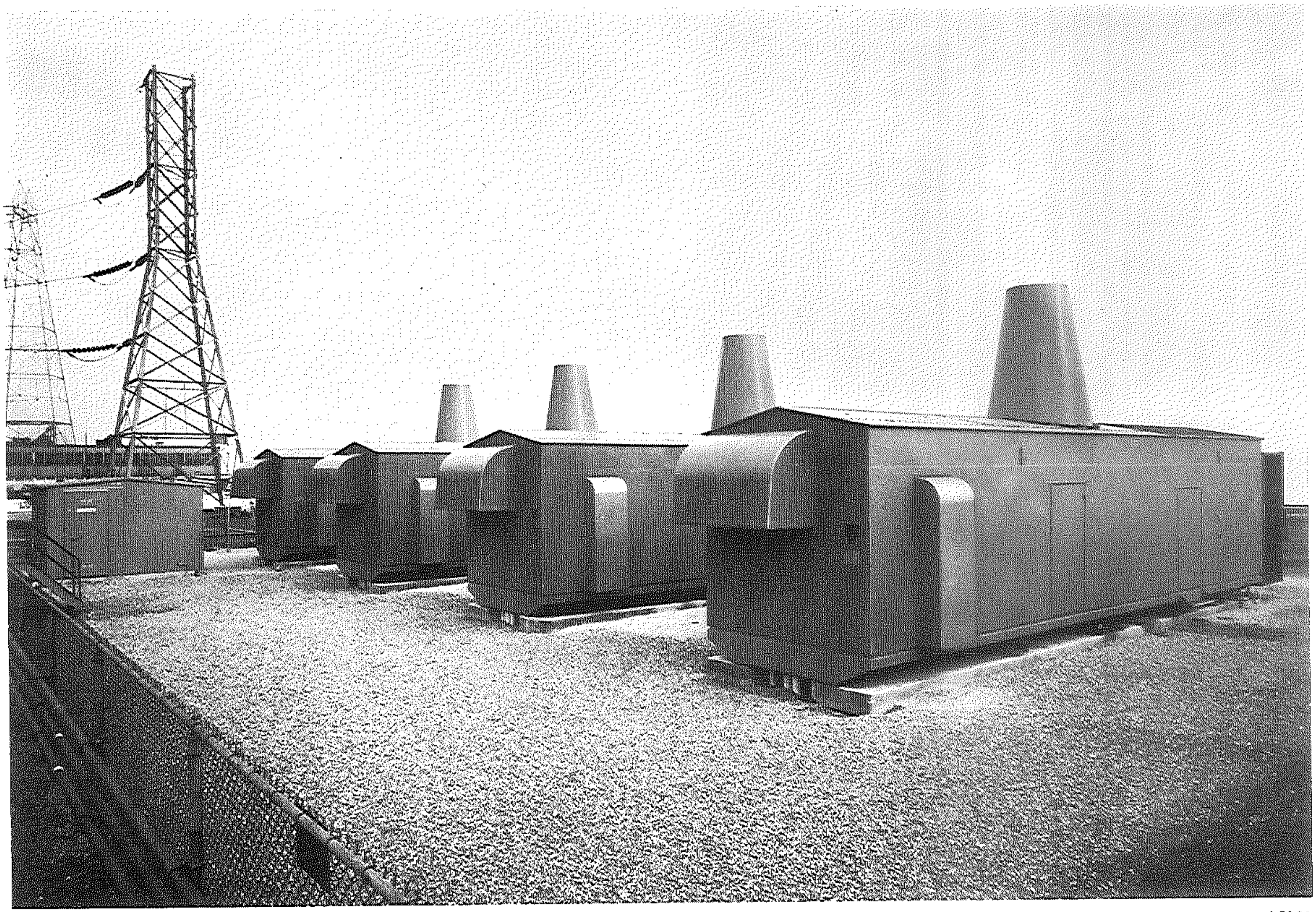


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Fig. 0-1 — Typical MU Type Power Plant Installation

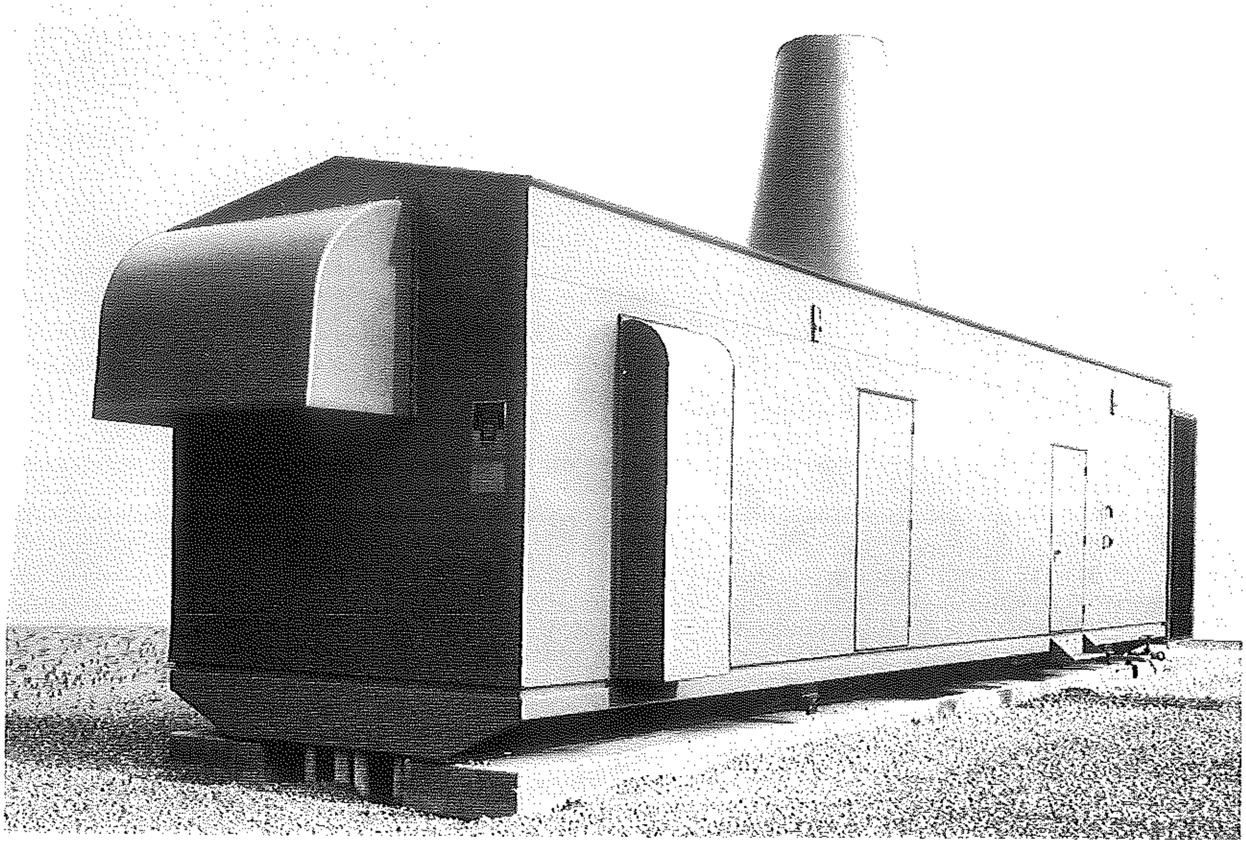

Fig. 1-1 — Typical MP Generating Unit

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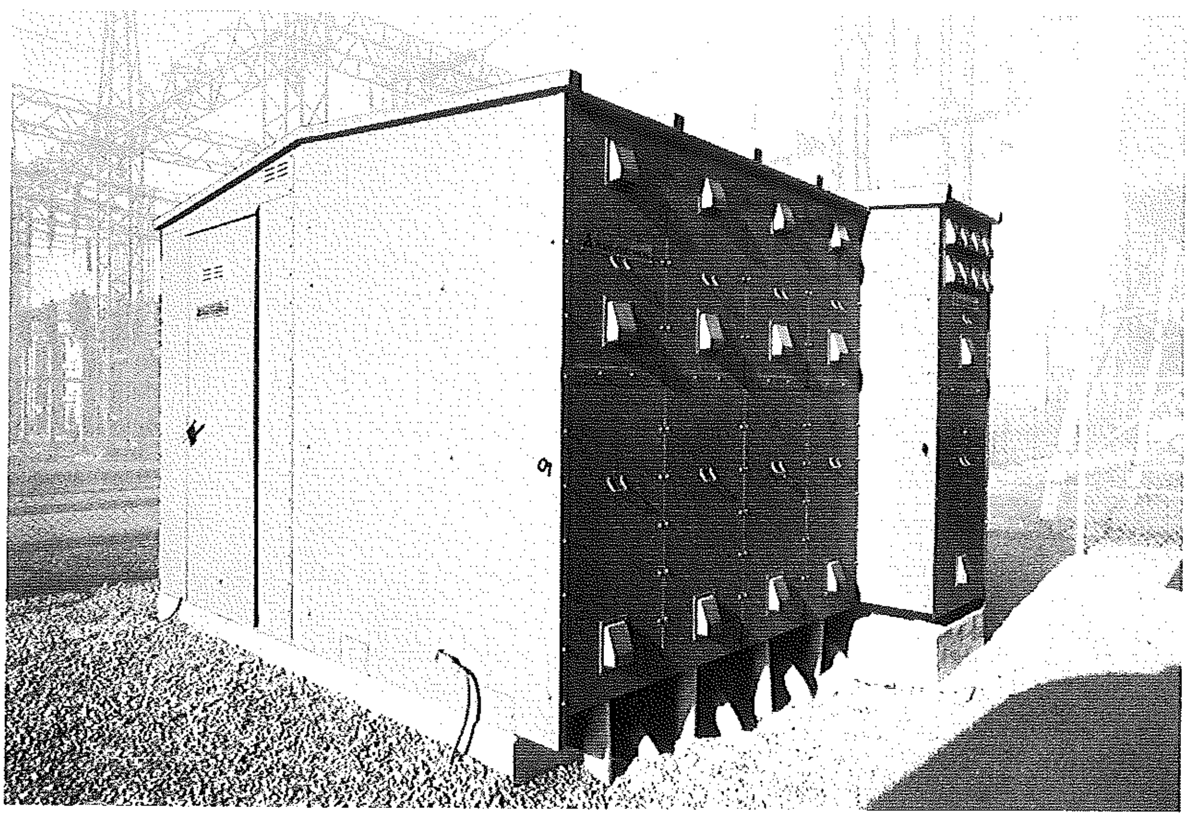

Fig. 1-2 — Typical Outdoor Switchgear Station

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SECTION 1

GENERAL DESCRIPTION

GENERAL

The General Motors Electro-Motive Division MU type power plant is designed for the specific purpose of providing AC power at 4160 volts, 3 phase, 60 cycle for peaking, spinning reserve, and base load operation. The MU type power plant may be modified to operate at lower voltage and frequency.

The MU type power plant consists of from one to six MP type diesel driven generating units, Fig. 1-1, and an outdoor switchgear station, Fig. 1-2. The plants are designed for automatic operation and require only start and stop signals which may be provided from the outdoor switchgear station or from a remote location. Controls are provided for manually operating the plants from the outdoor switchgear station. The manual controls are provided for use during inspections and when performing maintenance on the plant. The manual controls may also be used as back up controls if for any reason the automatic control circuitry is inoperative.

Full load operation in peaking mode is attained in three minutes or less after start signal is received. Refer to Fig. 1-3, for starting time of MU power plant when operating in peaking mode. Full load operation in dead line emergency start can be attained in approximately 90 seconds, but dead line emergency start should be used only in extreme emergency. Refer to Fig. 1-4, for starting time of MU power plant when operating in dead line emergency start mode.

MP TYPE GENERATING UNIT, Fig. 1-1

The MP type generating unit consists of a skid mounted metal enclosure housing a diesel engine, a synchronous generator, engine accessories, generator accessories, engine control cabinet, and an electrical control cabinet. The metal enclosure is sound-insulated and provides protection from the weather.

One generating unit in each MU type power plant is designated as the Master Generating Unit (MPA). The remaining generating units are designated as Auxiliary Generating Units (MPB). The MPA unit contains batteries, a battery charger, and fuel oil transfer pumps. The battery provides power for starting all engines in the power plant. The battery also supplies power for flashing the generator field of the first unit to start when the plant is used for starting under dead line conditions. The battery charger keeps the batteries fully charged. The fuel oil transfer pumps are used to transfer fuel oil from the fuel oil storage tank to the fuel oil day tank located on the MPA unit. Equalizer lines are connected between the MPA fuel oil day tank and MPB fuel oil day tanks so that fuel oil level in all fuel oil day tanks is approximately equal.

The diesel engine may be operated from within the MP enclosure, or from the switchgear station.

OUTDOOR SWITCHGEAR STATION, Fig. 1-2

The outdoor switchgear station is a sectionalized metal structure which contains all equipment necessary for manual or automatic operation of the MU type power plant. The switchgear station consists of one generator switchgear cubicle for each MP type generating unit in the MU installation and a single auxiliary switchgear cubicle that is common to all generating units in the installation.

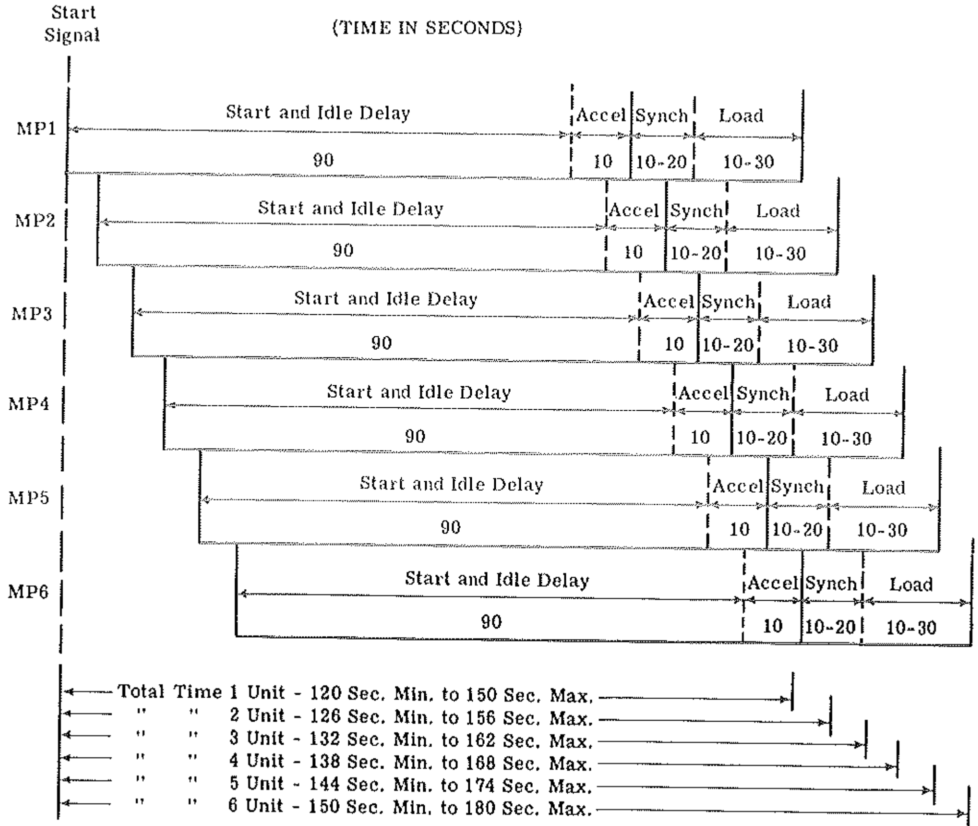

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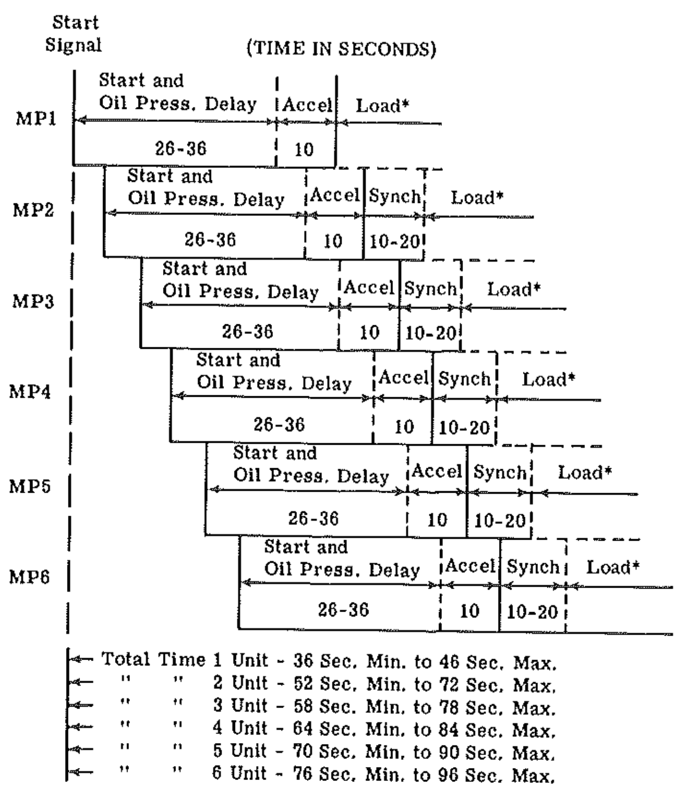
Fig. 1-3 — Starting Time Of MU Power Plant (Normal Start Peaking Duty)



* Load breaker closes after last unit has synchronized to MU bus. 14270

Fig. 1-4 — Starting Time Of MU Power Plant (Deadline Emergency Start)

Each generator switchgear cubicle contains an air magnetic circuit breaker located in the line between the generating unit and the MU power plant bus. The MU power plant bus is connected to bushings provided on the roof of the switchgear station. A modification to provide output through underground connections is available. The door of each generator switchgear cubicle contains relays and switches related to the specific generating unit connected to the circuit breaker.

The auxiliary switchgear cubicle contains transformers, control equipment, protective relays, and meters related to the power bus that is common to all generating units in the MU installation.

GENERAL OPERATING SEQUENCE

A brief description of MU plant operating sequence is given below. Detailed operating sequences are provided in other sections of this manual.

In normal peaking mode of operation, a start signal causes the stepping switch in the MPA unit to begin the starting sequence of the generating units. When a generating unit has started it sends a signal to the MPA unit, which causes the next unit to start. This cycle is repeated until all units have started. After a generating unit has started it will idle for approximately 90 seconds, then accelerate, building up speed and voltage. When speed and voltage has built up, the generating unit synchronizes voltage, phase, and frequency with the bus then closes its circuit breaker and begins to share the load. The generating unit increases load until its output is at full rated load.

At customers option, a remote stop/plant stop switch can be furnished which will stop all generating units. The local control box located within the switchgear station detects the stop signal then sends a stop signal to each generating unit. Upon receiving a stop signal the generating units will unload, the breakers will open, and the engines will idle until cool and then stop.

Protective circuits and devices are provided to handle abnormal conditions. A number of abnormal conditions, as shown on the annunciator of each generating unit, will cause lockouts and either stop the engine or prevent it from starting. When a generating unit is stopped by certain faults relating directly to the engine, the cause must be corrected and the annunciator manually reset before the unit can be restarted. Other annunciator fault indications may be reset from a remote location, and if the fault does not persist normal operation will result.

SECTION 2

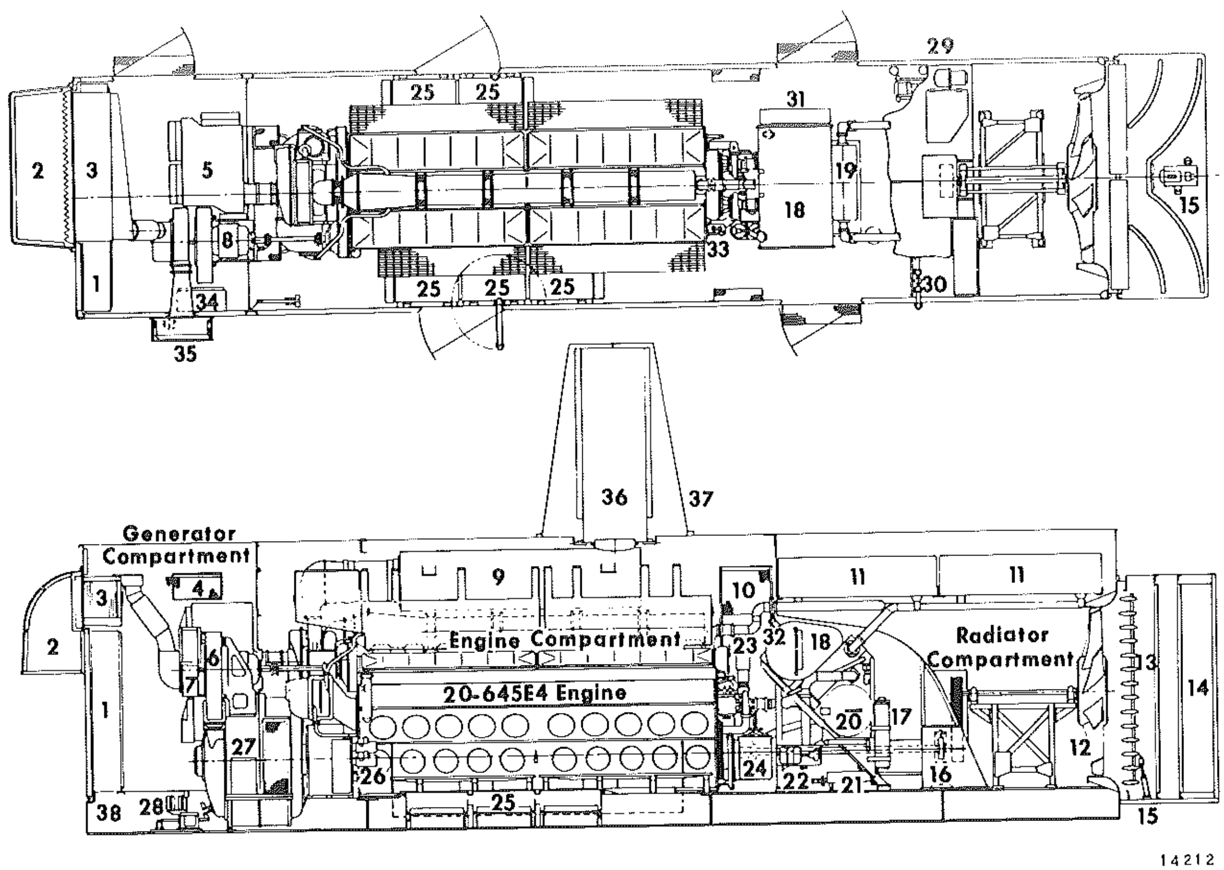
MP TYPE GENERATING UNIT EQUIPMENT AND SYSTEMS

GENERAL

The MP type generating unit consists of a diesel engine directly coupled to a synchronous generator equipped with a regulated static type exciter. The unit also contains an engine control panel, an electrical control panel, and the required engine supporting auxiliaries such as oil coolers, oil filters, engine water cooling system, engine exhaust snubber, and fuel oil system. The general arrangement of the equipment is shown in Figs. 2-1 and 2-2.

DIESEL ENGINE, Fig. 2-3

The prime mover in the MP type generating unit is the Model 20-645E4, 20-cylinder, 45 degree Vee, two-stroke cycle,



1. Generator Control Cabinet
2. Air Intake Sound Hood
3. Air Intake Filter
4. Static Exciter
5. Engine Air Intake Filters
6. Generator Blower
7. Air Filter Dust Bin Blower
8. Blower Drive Support
9. Exhaust Silencer With Heat Shield
10. Engine Room Vents
11. Engine Cooling Radiators
12. Radiator Cooling Fan
13. Radiator Shutters
14. Cooling Air Intake Sound Hood
15. Shutter Actuating System
16. Fuel Day Tank
17. Lube Oil Circulating Pump Filter
18. Engine Water Tank And Gauge
19. Lube Oil Cooler
20. Engine Lube Oil Filter
21. Immersion Heater
22. Lube Oil Circulating Pump
23. Engine Governor
24. Lube Oil Strainer And Filler
25. Batteries ("Master A" Unit Only)
26. Engine Starting Motors
27. Synchronous Generator
28. Generator Output Connections And Metering Transformers
29. Fuel Transfer System ("Master A" Unit Only)
30. Fuel Day Tank Level Gauge
31. Engine Control Cabinet
32. Engine Water Tank - Filling Cap
33. Fuel Pressure Filter
34. Battery Charger ("Master A" Unit Only)
35. Sound Hood - Dust Bin Blower Discharge
36. Engine Exhaust Stack
37. Engine Exhaust Shroud
38. Power CT's (When Fitted)

Fig. 2-1 — MP Type Generating Unit — General Arrangement

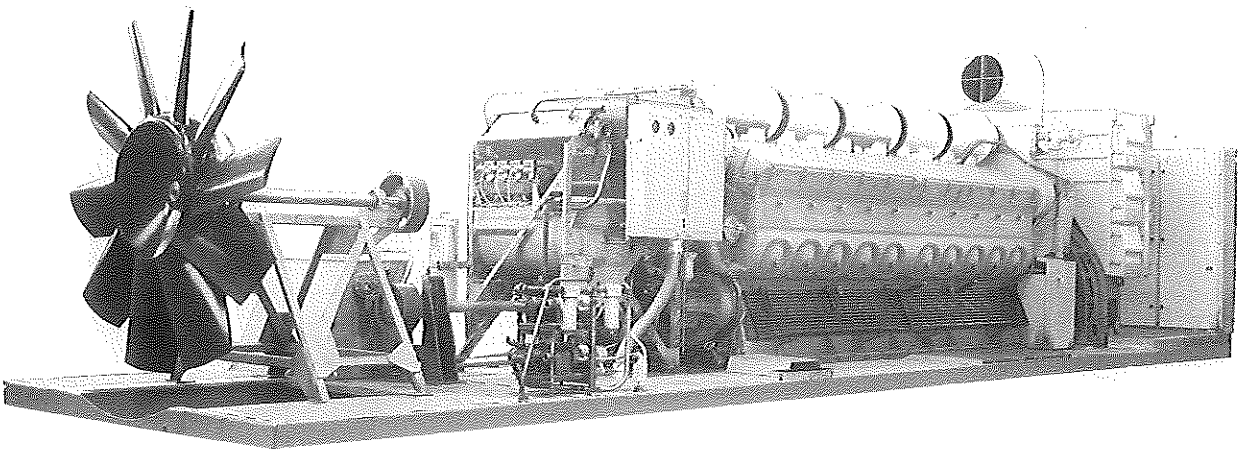


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Fig. 2-2 — MP Type Generating Unit Without Housing

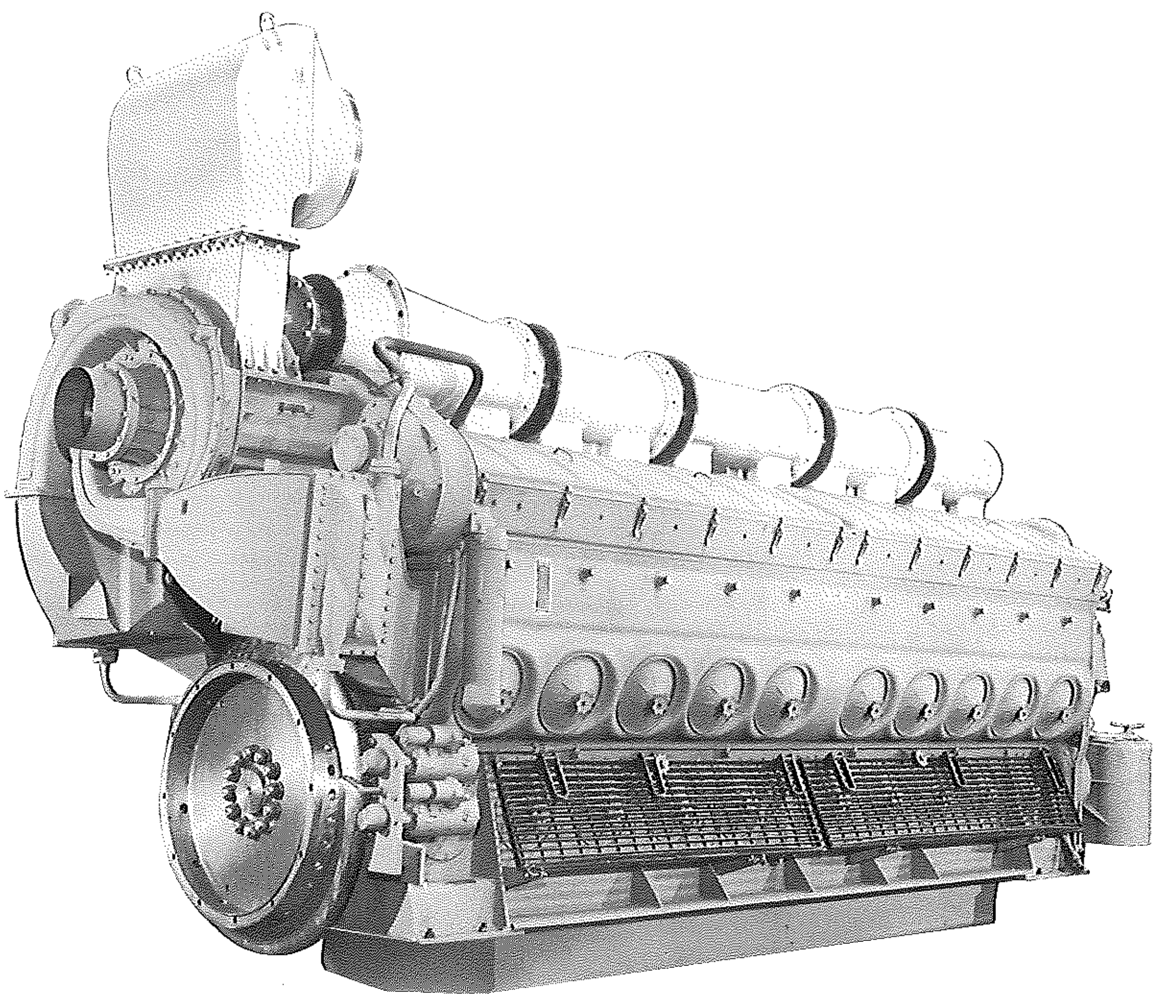

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Fig. 2-3 — Model 645E4 Turbocharged Diesel Engine turbocharged diesel engine. Each cylinder has a 9-1/16" bore with a 10" stroke, providing a piston displacement of 645 cu. in. For a more detailed explanation of the diesel engine refer to the Engine Maintenance Manual.

FUEL OIL SYSTEM, Fig. 2-4

The fuel oil system consists of the generating unit fuel oil system and the fuel oil transfer system.

GENERATING UNIT FUEL OIL SYSTEM, Fig. 2-4

The fuel oil system for each generating unit consists of a fuel oil day tank, fuel pump, fuel suction strainer, engine mounted fuel filter, sight glasses, fuel pressure gauge, fuel intake manifolds, fuel injectors, and associated plumbing. Refer to Engine Maintenance Manual for detailed description of fuel intake manifolds and fuel injectors.

FUEL OIL DAY TANK

The fuel oil day tank is a 130 gallon auxiliary fuel oil tank, supplied with each engine. The fuel oil day tank serves as a fuel oil supply source for the engine and as a reservoir for unused fuel returned from the engine fuel injectors. The fuel oil day tank is equipped with a fuel level gauge and with a vent to atmosphere.

FUEL SIGHT GLASSES, Fig. 2-5

Two fuel sight glasses, the fuel return sight glass and the fuel bypass sight glass, are located on the engine mounted fuel filter housing to provide visual indication

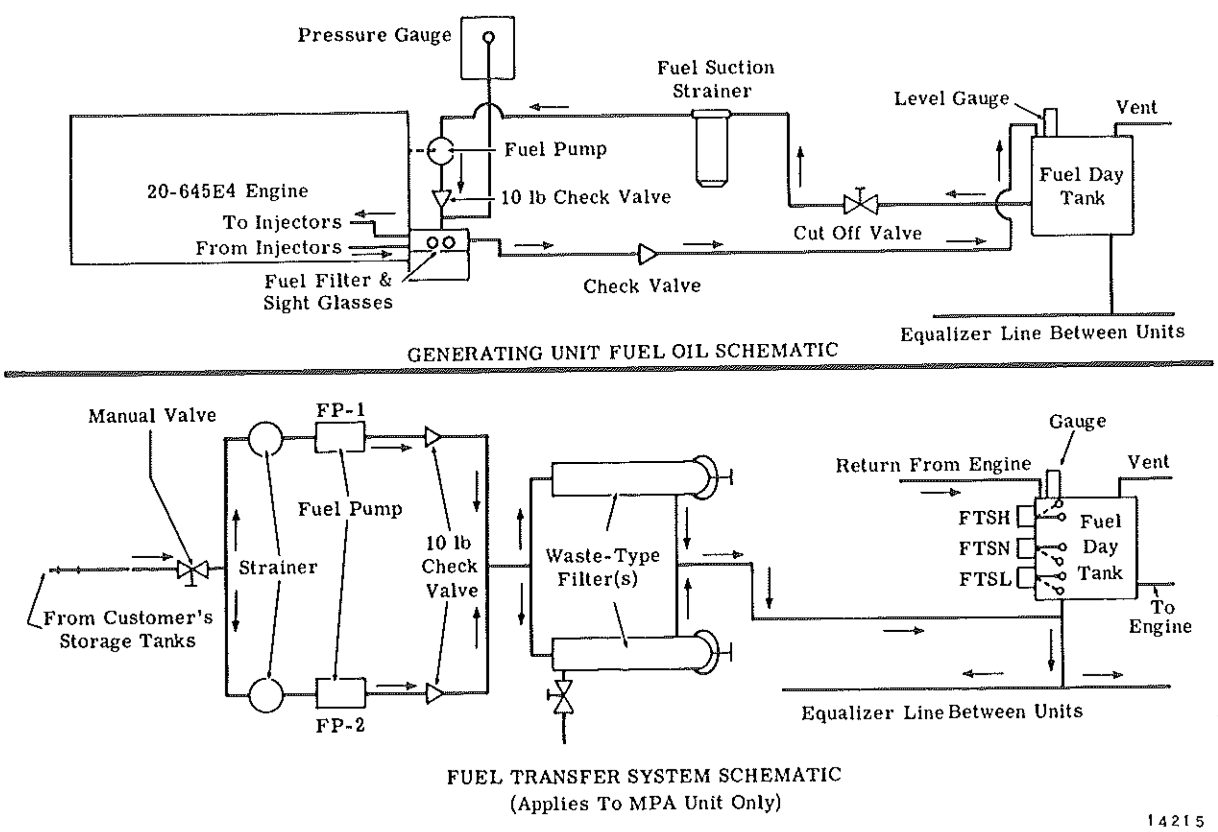


Fig. 2-4 — Fuel Oil System Simplified Schematic Diagram

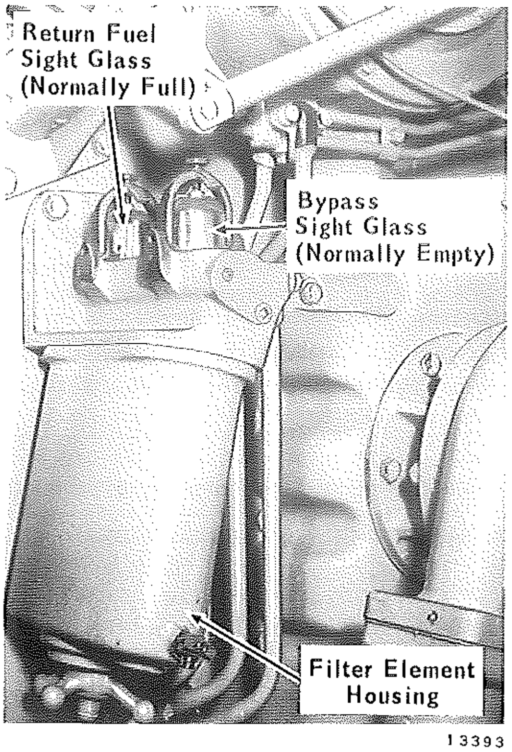


Fig. 2-5 — Fuel Oil Sight Glasses

of the fuel system condition. During normal operation the fuel return sight glass, mounted nearest the engine, should be full of fuel, clear, and free of bubbles. A 10 lb. relief valve inside the fuel return sight glass provides a back pressure, thus maintaining a positive supply of fuel at the engine injectors. When the back pressure exceeds 10 lbs. the relief valve opens allowing the excess fuel to return to the fuel oil day tank.

The fuel bypass sight glass, mounted farthest from the engine, is connected in the fuel line between the fuel oil pump and the double element engine mounted fuel oil filter. A 60 lb. relief valve is located in the fuel bypass sight glass. If the double element engine mounted fuel oil filter becomes clogged, the relief valve will open when pressure exceeds 60 lbs. The open relief valve allows fuel oil to flow through the fuel bypass sight glass and return to the fuel oil day tank instead of flowing into the engine fuel manifold.

If more than a trickle of fuel is visible in the fuel bypass sight glass, engine failure will probably result from lack of fuel to the fuel injectors.

FUEL PUMP, FUEL SUCTION STRAINER, AND FUEL FILTER

The engine mounted fuel pump draws fuel from the fuel oil day tank through the fuel suction strainer. The fuel oil is then forced through a 10 lb. check valve, the double element engine mounted fuel filter, and into fuel manifolds that extend along both banks of the engine. A fuel pressure gauge is installed in the fuel line between the 10 lb. check valve and the double element engine mounted fuel filter. Fuel injectors force fuel from the manifolds into the engine cylinders. The fuel pump delivers more fuel to the injectors than the engine can burn. The excess fuel cools and lubricates the injectors, then is returned to the fuel oil day tank through the return fuel sight glass and a check valve.

FUEL OIL TRANSFER SYSTEM, Fig. 2-4

The MPA generating unit has a fuel oil transfer system consisting of two fuel oil transfer pumps, a suction strainer for each pump, check valves, waste type filter(s), and float level gauges and switches. The purpose of this system is to transfer fuel oil from the main fuel oil storage tank to the fuel oil day tanks of the generating units. The fuel level is controlled by float switches located in the fuel oil day tank of the MPA generating unit. The fuel level in the fuel oil day tanks of the MPB generating units is maintained by fuel oil equalizer lines. Refer to the following paragraph and to lower portion of Fig. 2-4 for operation of the fuel oil transfer system.

As fuel is consumed and fuel level in the fuel oil day tank of the MPA unit decreases, the fuel transfer switch normal (FTSN) activates the No. 1 fuel oil transfer pump to maintain normal fuel oil level. If fuel level drops below the normal level, fuel transfer switch low (FTSL) activates the No. 2 fuel oil transfer pump. If fuel level rises above the normal level, fuel transfer switch high (FTSH) de-energizes the circuit to No. 1 and No. 2 fuel oil transfer pumps. If the fuel level drops below the normal level or rises above normal level, the FUEL TRANSFER light on the MPA unit annunciator comes on indicating a fuel oil transfer fault. The fault indication does not cause a shutdown; however, operation of the fuel oil transfer system should be checked.

LUBRICATING OIL SYSTEM, Fig. 2-6

Refer to the following paragraphs and to Fig. 2-6 for description of that portion of the lube oil system that is external to the engine. Refer to Engine Maintenance Manual for description of internal portion of the lube oil system.

During normal operation, the engine driven scavenging oil pump draws lube oil,

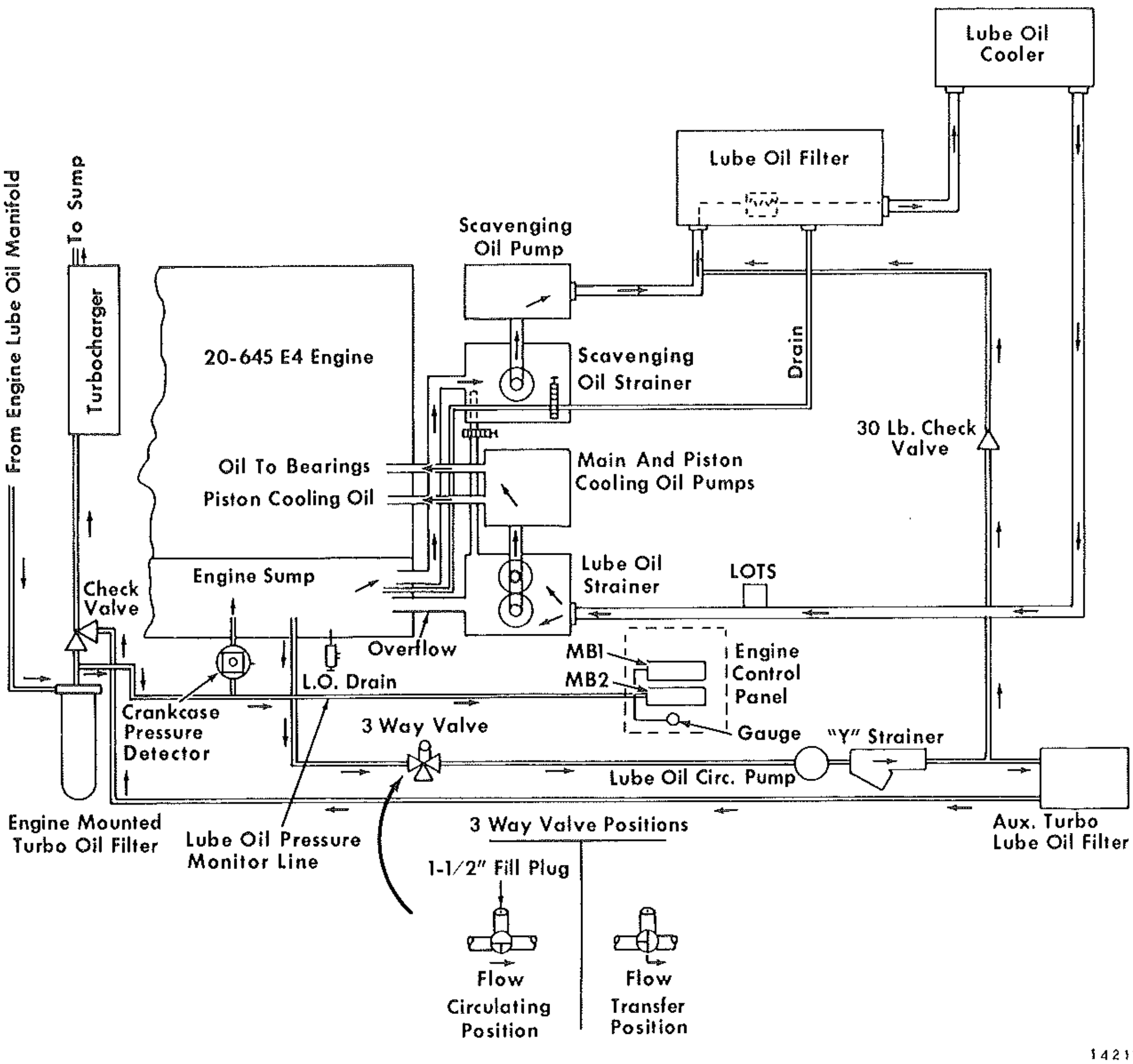


Fig. 2-6 — Lube Oil System Simplified Schematic Diagram through the scavenging oil strainer, from the engine sump. The oil is then forced through the lube oil filter and the lube oil cooler and into the lube oil strainer housing. The engine driven main lube oil and piston cooling pumps draw lube oil, through the lube oil strainer, from the lube oil strainer housing. The lube oil is then forced to most of the moving parts of the engine, including the turbocharger. After lubricating the moving parts of the engine, the lube oil returns to the engine sump. Since the scavenging oil pump supplies more lube oil to the lube oil strainer housing than can be removed by the main lube oil and piston cooling pumps, the excess oil flows through the overflow line and into the engine sump.

A lube oil pressure monitor line is connected into the lube oil pressure line at a point in the system where the greatest pressure drop has occurred. An oil pressure gauge and two main bearing oil pressure switches, MB1 and MB2, are connected into the monitor line. A crankcase pressure detector is connected between the lube oil pressure monitor line and the engine sump. Main bearing oil pressure switch MB1 prevents engine speed from increasing above idle until satisfactory oil pressure is obtained. Main bearing oil pressure switch MB2 causes engine shutdown if satisfactory oil pressure is not obtained within a specified time after engine reaches rated speed. The crankcase pressure detector causes oil to be dumped from the lube oil pressure monitor line into the sump, whenever a positive pressure is developed in the crankcase. Abnormally low oil pressure at MB1 and MB2 will result in engine shutdown and an engine fault indication on the annunciator. Low oil pressure at MB1 and MB2 may be caused by low system oil pressure or by tripping of the crankcase pressure detector.

AUXILIARY LUBE OIL SYSTEM, Fig. 2-6

Each generating unit is equipped with an auxiliary lube oil system. The purpose of the auxiliary lube oil system is to provide lube oil to remove residual heat from the turbocharger bearings immediately after shut down and to maintain engine oil temperature during engine shut down.

The lube oil circulating pump draws lube oil from the engine sump and forces a portion of the lube oil through the lube oil filter, lube oil cooler, and into the lube oil strainer housing then back to the engine sump. The remainder of the lube oil is forced through the auxiliary turbo lube oil filter, turbocharger, then back to the sump.

The lube oil cooler is used to heat the lube oil during engine shutdown. The heated lube oil ensures proper lubrication when starting a cold engine. When the engine is shut down, water is heated by the immersion heater, Fig. 2-9. The heated water flows through tubes in the lube oil cooler by thermo-siphon action. Heat is transferred to the lube oil as the lube oil flows through the lube oil cooler. This method of heating the lube oil utilizes the large surface area of the lube oil cooler and prevents carbonization that might occur if the oil was heated directly.

AUTOMATIC COLD IDLE

The immersion heater may be unable to maintain adequate lube oil temperature during extremely cold weather or if a fault develops in the immersion heater circuit. If the lube oil temperature drops below a predetermined value, the low oil temperature switch LOTS closes to energize LTR which issues an engine start command. The engine will start and idle until lube oil temperature increases to a predetermined value, the engine continues to idle for another 11.5 minutes after which LOTS will open causing the engine to shut down. The sensing element of LOTS is located in the lube oil line between the lube oil cooler and the lube oil strainer.

ADDING OR DRAINING LUBE OIL

Engine oil level should be checked with the engine hot and running at idle speed, but if necessary, oil level may be checked with engine at operating speed. A dipstick, Fig. 2-7, is located at the right side of the engine. It should show a level between LOW and FULL when the engine is running. If the oil level is checked with the engine stopped, the reading on the dipstick will usually be above the FULL mark.

Oil may be added in small amounts with the engine running or stopped. When oil is added to the system, it should be poured into the strainer housing through the opening having the square cap as shown in Fig. 2-8. Should the round caps be removed while the engine is running, hot oil under pressure will come from the openings and possibly cause personal injury.

If local maintenance procedures require that oil be added in large amounts, a service boom can be secured with the MP unit as an extra modification. The boom can be employed to hoist oil barrels into position to be emptied onto the engine top deck. This can be done only with the engine shut down, for oil will spray out of the top deck of an operating engine.

NOTE: Overfilling of the engine may cause foaming of the oil in the accessory drive and camshaft gear trains. The oil pan aspirator may become saturated and the engine may shut down due to positive crankcase (oil pan) pressure.

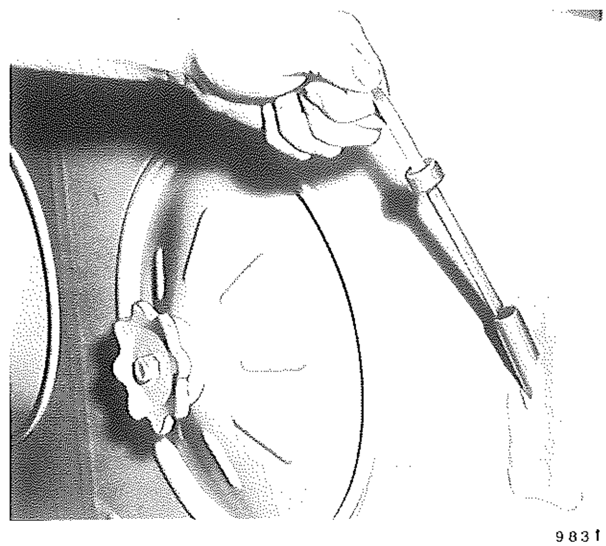


Fig. 2-7 — Checking Oil Level

Oil may also be added or drained through use of the 3-way valve and circulating pump. An elbow and pipe plug are provided to facilitate transfer of the lube oil from a drum to the system. With the valve in the transfer position, suction can be applied at opening of 3-way valve, Fig. 2-6. When draining the lube oil system, the oil filter drain valve and the strainer drain valve, Fig. 2-8, located in the lube oil strainer housing, should be open.

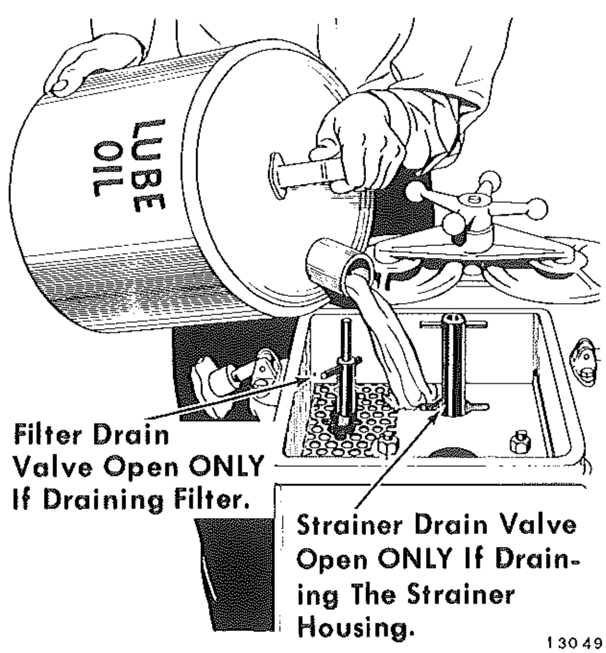


Fig. 2-8 — Adding Oil To Engine

If the maintenance conditions require more rapid lube oil transfer, it is possible for the user to provide his own high volume pump and piping for transfer through the oil pan handholes.

COOLING SYSTEM

Refer to the following paragraphs and to Fig. 2-9 for description of that portion of the engine cooling system that is external to the engine. Refer to Engine Maintenance Manual for description of internal portion of engine cooling system.

Two centrifugal pumps, mounted on front of engine and driven from the accessory gear train of the engine, circulate water through the cooling system. Heated water flows from the engine discharge manifold into the radiators. From the radiators water flows through the lube oil cooler to the water pumps then back through the engine.

A temperature control manifold is mounted on the accessory rack and connected into the cooling system line at inlet to the oil cooler. A shutter control switch (TB), an engine water temperature switch (ETS), and an immersion heater temperature control switch (TC) are mounted on the temperature control manifold. Shutter control switch (TB) is a two position thermal switch. Operation of the switch is controlled by temperature of the water within the temperature control manifold. If water temperature is below a specified value, TB will operate to cause the shutters to move toward the closed position. As the shutters move toward the closed position, less cooling air comes into contact with the radiator fins and water temperature increases. If water temperature is above a specified value, TB will operate to cause the shutters to move toward the open position, more cooling air comes into contact with the radiator fins, and water temperature decreases. A timer relay (T) is incorporated into the control circuit to reduce over control of the shutters and thereby preventing a continuous opening and closing of the shutters. Timer relay (T) supplies current to TB for a specific time, at timed intervals. This intermittent operation allows water temperature to partially stabilize at each position of the shutters, thereby reducing over control of the shutters.

Immersion heater temperature control switch (TC) operates to control power to the immersion heater elements during engine shut down. Water heated by the immersion heater circulates through the lube oil cooler, by thermo-siphon action and maintains the lube oil temperature at a value that ensures proper lubrication when starting a cold engine. If water temperature rises above a predetermined value, TC operates to remove power from the immersion heater. When water temperature drops below the predetermined value, TC operates to apply power to the immersion heater.

The engine water temperature switch (ETS) operates to issue an ENGINE TEMPERATURE fault and causes the engine to shut down, when water in the engine approaches the boiling point.

The radiators are mounted so that water will drain from the radiators into the water tank during engine shut down. Anti-freeze is not required, as heat from the immersion heater and the "automatic cold idle" feature of the engine supplies sufficient heat to prevent the water from freezing.

FILLING THE COOLING SYSTEM

The coolant used in the engine cooling system should be made up and tested in

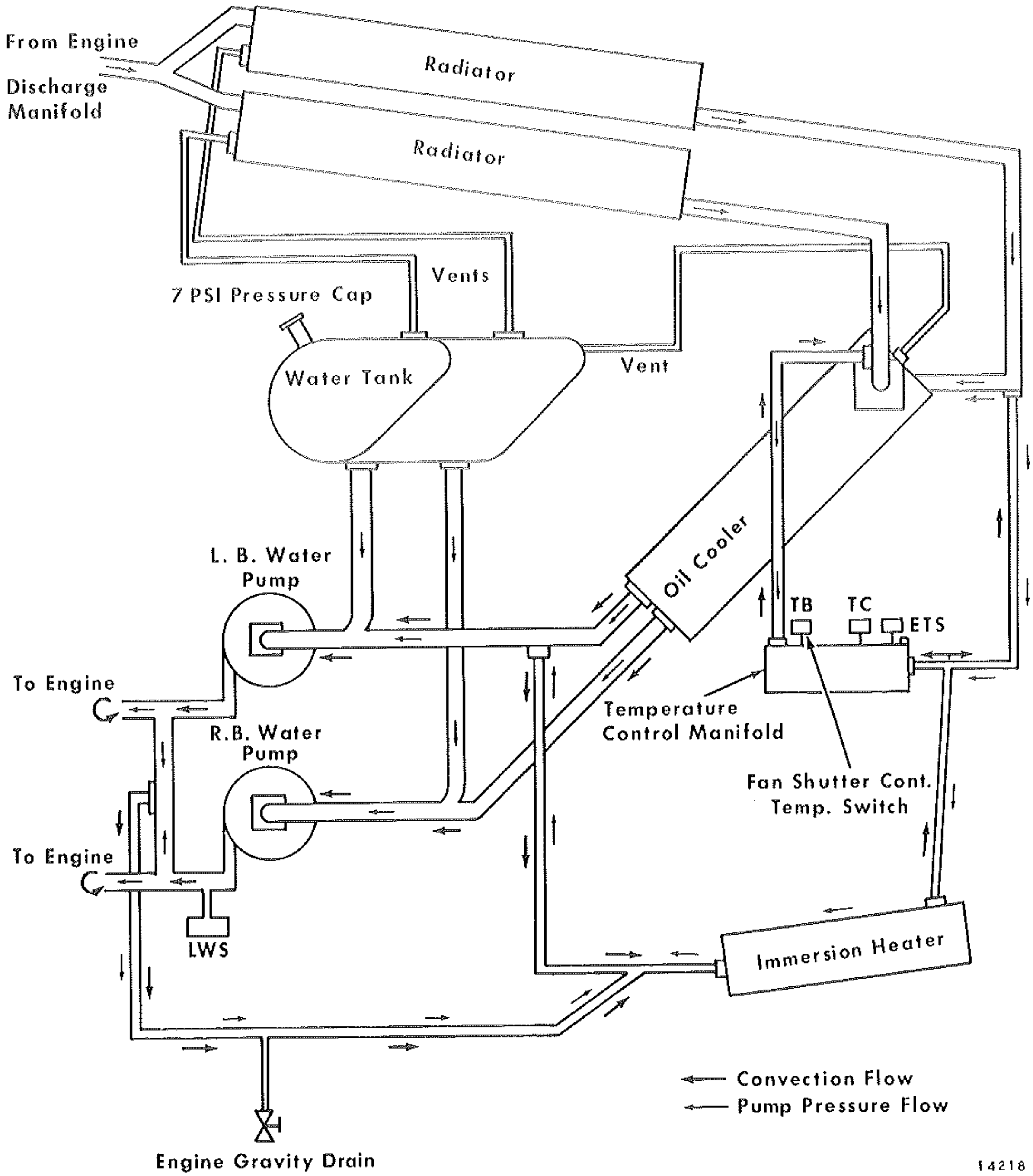


Fig. 2-9 — Cooling System Simplified Schematic Diagram

accordance with Maintenance Instruction 1748.

CAUTION: If the cooling system of a hot engine has been drained, do not refill until the engine cools. A sudden change in temperature may cause damage to the engine.

The cooling system is filled through the engine water tank filling cap located on top of the water tank within the generating unit housing. A water level sight glass is located on the tank. The water tank contains approximately 200 gallons of coolant. Coolant should be maintained at the level indicated on the instruction plate located by the sight glass. Observe that the full and low level calibration is different for an engine when running than for an engine that is shut down.

ENGINE SPEED GOVERNOR

The engine speed governor is a Woodward, EG series, electric type governor consisting of an EG-B10 hydraulic actuator, a peaking load control box, and an EG-A control box. The governor system may be used on single or paralleled generating units and can be operated as a speed droop governor or as an isochronous governor.

An isochronous governor installed on a generating unit operating alone maintains constant speed for all loads within the capacity of the generating unit. Two or more generating units equipped with EG series governors, operating with isochronous control, may be operated in parallel. The paralleled generating units with isonchronous control will render proportional load division.

One or more generating units equipped with EG series governors, operating as speed droop governors, may be paralleled with generating units equipped with dissimilar governors or with an infinite bus (commercial power lines). The load carried by the generating unit or generating units equipped with the speed droop governor will be a function of governor speed setting and speed droop setting.

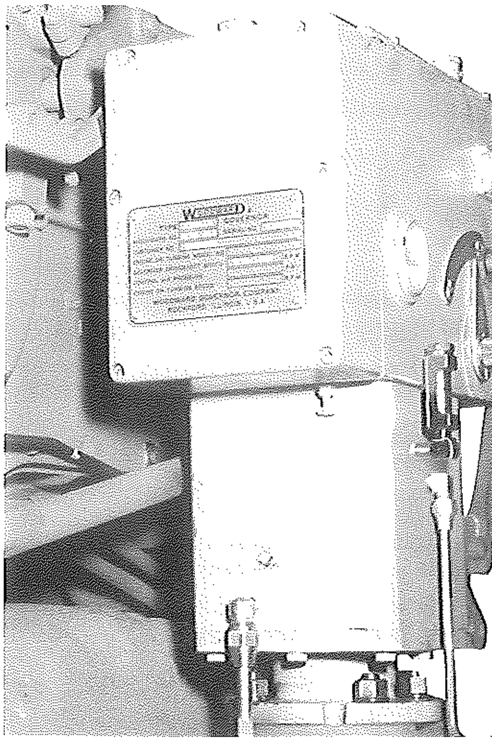
The engine speed governor consists of two independent speed controlling systems, a centrifugal governor which is contained in the EG-B10 hydraulic actuator and an electrical governor consisting of the peaking load control box, the EG-A control box, and a transducer which is located in the EG-B10 hydraulic actuator. When starting a generating unit, the centrifugal governor is in control until the engine is near synchronous speed. The electrical governor then assumes control to hold the engine at synchronous speed. The centrifugal governor will also assume control any time the control signal to the transducer is interrupted.

EG-B10 HYDRAULIC ACTUATOR, Fig. 2-10

The EG-B10 hydraulic actuator is physically mounted on the engine governor drive assembly and will be considered as an engine component. A brief description of the actuator is provided in the following paragraphs. Refer to the Engine Maintenance Manual for detailed description.

The purpose of the EG-B10 hydraulic actuator is to control fuel flow to the engine, as necessary, to maintain the generating unit at a constant predetermined speed. The actuator contains a complete centrifugal governor and the output stage (an electrically operated transducer) of the electrical governor. During normal operation, the transducer controls fuel to the engine in response to a control signal received from the EG-A control box. If no signal is received from the EG-A control box, the transducer is inoperative and the centrifugal governor assumes control of engine speed. Engine speed is approximately 6% higher when under control of the centrifugal governor than when under control of the transducer. Therefore, the centrifugal governor provides "backup" control for the transducer.

The actuator contains two governor speed setting solenoids, an "idle speed" solenoid (GS-I) and a "full speed" solenoid (GS-II). When GS-1 is energized, all fuel to the engine is shut off. When GS-1 is de-energized, the fuel injector racks advance to the idle speed setting of the centrifugal governor, allowing the engine to run at



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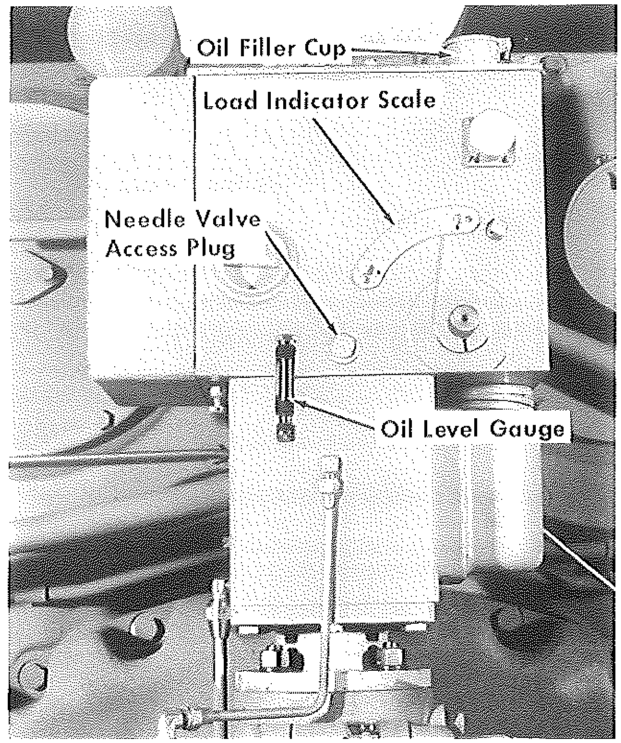

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Fig. 2-10 — EG-B10 Hydraulic Actuator

idle speed. When GS-II is energized, the fuel injector racks advance to the full speed setting of the centrifugal governor, allowing engine speed to increase to approximately 6% above synchronous speed. However, under normal operating conditions, a signal from the EG-A control box causes the transducer to assume control and regulate the engine at synchronous speed.

The actuator also contains two fuel limit solenoids, a "start fuel limit" solenoid (GSS) and a "loading limit" solenoid (LS). During engine start, the "start fuel limit" solenoid (GSS) is energized and limits travel of the fuel injector racks to approximately 1/3 rated load position. The 1/3 position reduces heavy exhaust smoke that would result from overfueling during starting. After the engine is started and speed has increased to approximately 200 RPM, GSS is de-energized and allows the fuel racks to move toward the full rated load rack position. During heavy load conditions, such as deadload pickup, the "loading limit" solenoid (LS) allows the fuel injector racks to travel to the maximum fuel position. This allows the unit to operate above normal fuel load rating.

PEAKING LOAD CONTROL BOX

The peaking load control box has three primary functions:

1. Provides a signal to the EG-A control box for automatically synchronizing the frequency of the oncoming generating unit with the bus frequency prior to closing of the circuit breaker.

2. Automatically closes the circuit breaker when oncoming generating unit is in phase with the bus.

3. Provides a signal to the EG-A control box for automatically maintaining a constant load on the generating unit,

operating in peaking mode, after the circuit breaker is closed.

The peaking load control box consists of a motor driven speed reference, an automatic synchronizer, a synchrophaser, a circuit for closing the circuit breaker, and an adjustable load reference. Refer to Fig. 2-11 and to the following paragraphs for description of the peaking load control box.

MOTOR DRIVEN SPEED REFERENCE

The motor driven speed reference control provides a signal to the EG-A control box for automatically synchronizing the frequency of the oncoming generating unit with bus frequency prior to closing of the circuit breaker. After the circuit breaker closes, the motor driven speed reference control provides a signal to the EG-A control box for automatically maintaining a constant load on a generating unit operating in peaking mode. The motor driven speed reference control also provides a signal to the EG-A control box when two or more generating units are operating in parallel in the dead line mode. This signal provides automatic load distribution between the paralleled generating units. The percentage of load provided by a generating unit, when operating in parallel in the dead line mode, is determined by the load characteristics of the individual generating unit. The load characteristics of a generating unit is largely determined by the engine speed governor; therefore, for most efficient operation of the MU plant it is necessary that each engine speed governor be properly adjusted prior to placing the MU plant into operation.

Output of the speed reference control is determined by the position of the movable contact on the speed reference control. The movable contact is positioned by a bi-directional motor. Signals to operate the bi-directional motor are provided from the automatic synchronizer section and the adjustable load reference section.

AUTOMATIC SYNCHRONIZER

The automatic synchronizer provides a signal to the EG-A control box for automatically synchronizing the frequency of the oncoming generating unit with the bus frequency, prior to closing of the circuit breaker.

The automatic synchronizer contains two frequency sensors. One of the frequency sensors is connected to the output of the oncoming generating unit, the second frequency sensor is connected to the bus. Each frequency sensor provides a DC output that is proportional to the frequency sensed. The difference in the two DC voltages (error signal) is fed through the zero adjust control and the synchronizer gain control into a solid state switch. The error signal causes the solid state switch to operate, energizing relay K2 or K3 depending upon the polarity of the error signal.

If the frequency of the oncoming generating unit is lower than bus frequency, the polarity of the error signal will be positive causing relay K2 to be energized. When relay K2 is energized, the "raise" contact in series with the speed reference control driving motor closes, causing the driving motor to drive the speed reference control to a position that causes an increase in the output of the speed reference control. If frequency of the oncoming generating unit is higher than bus frequency, the polarity of the error signal will be negative and relay K3 will be energized. When relay K3 is energized, the "lower" contact in series with the speed reference control driving motor closes, causing the driving

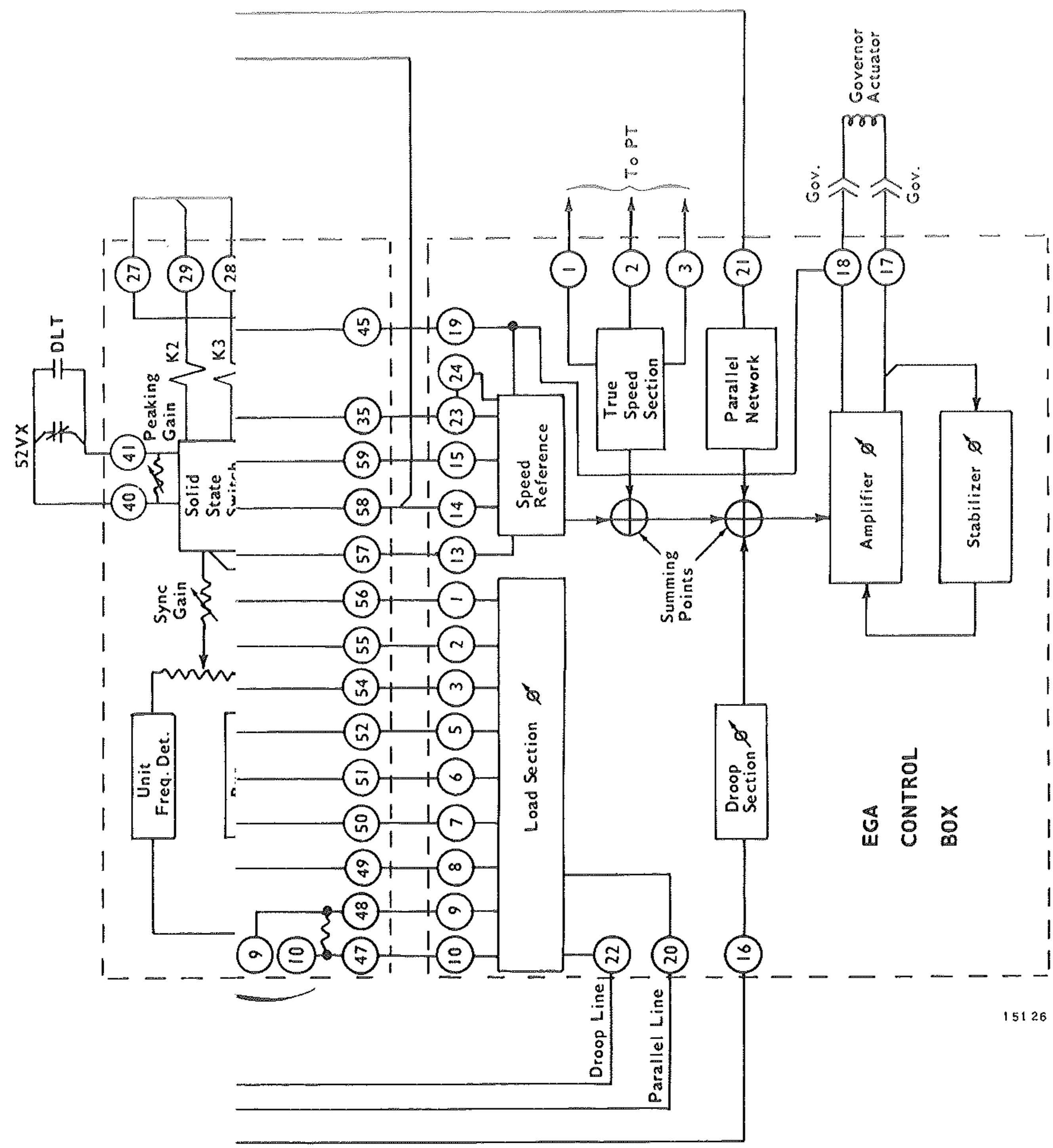


Fig. 2-11 — Simplified Schematic Of Peaking Load Control Box And EG-A Control Box

motor to drive the speed reference control to a position that causes a decrease in the output of the speed reference control.

Output of the speed reference control is fed to the speed reference section of the EG-A control box. Output of the speed reference section is "summed" with other signals in the EG-A control box, then amplified and applied to the EG-B10 hydraulic actuator transducer. With an increase in the output from the speed reference control, the EG-B10 hydraulic actuator operates to increase fuel supply to the engine, causing engine speed and frequency of oncoming generating unit to increase. With a decrease in the output from the speed reference control the EG-B10 hydraulic actuator operates to decrease fuel supply to the engine, causing engine speed and frequency of oncoming generating unit to decrease.

The frequency difference or "error signal" to the solid state switch has a built in "dead band." This "dead band" is provided to reduce "hunting" of the synchronizer and ensures more stable operation. The synchronizer gain control is provided to adjust the width of the dead band. The zero adjust control is provided to balance the frequency sensors and to set the frequency difference between the oncoming generating unit and the bus to approximately 0.2 cps.

SYNCHROPHASER SECTION

The synchrophaser detects phase displacement between the output of the oncoming generating unit and the bus. When the phase angle decreases to 30°, the synchrophaser section operates to energize the circuit breaker closing section, allowing the circuit breaker to close upon command from the circuit breaker closing section.

The synchrophaser section contains a phase sensor, a solid state switch, and a relay. The phase sensor is connected between the bus and the oncoming generating unit. The phase sensor provides a DC output that is proportional to the phase difference between the bus and the oncoming generating unit. Output of the phase sensor (phase error signal) is applied to the solid state switch so that the phase error signal opposes the fixed bias of the solid state switch. When the phase angle between the bus and the oncoming generating unit decreases to 30°, the phase error signal has decreased to a small value and permits operation of the solid state switch which energizes relay K4. Operation of relay K4 energizes the circuit breaker closing section allowing the circuit breaker closing section to close the circuit breaker when the oncoming generating unit and the bus are in phase.

CIRCUIT BREAKER CLOSING SECTION

The circuit breaker closing section is provided to control the closing action of the circuit breaker when the bus and the oncoming generating unit are in phase.

The circuit breaker closing section contains a phase sensor, a solid state switch, a control for adjusting circuit breaker closing time, and a relay. Operation of the phase sensor in this section is the same as the phase sensor in the synchrophaser, except in this section the solid state switch does not operate until the phase angle decreases to approximately 15°. Operation of the solid state switch energizes relay K1 which applies power to the breaker closing circuit. The point at which relay K1 should be actuated depends upon the rate of change of the phase angle and the time required for closing the breaker. The rate of change of the phase angle is an adjustable function of the automatic synchronizer circuit. A breaker closing time control, connected between the phase sensor and the solid state switch, is provided to compensate for small differences in breaker closing time.

ADJUSTABLE LOAD REFERENCE SECTION

The adjustable load reference section is provided to ensure that the generating unit operates under constant load when paralleled with an infinite bus. The load reference is adjustable from approximately 65% to 120% of full load of the generating unit. The load reference is usually adjusted for 100% full load operation.

Output of the adjustable load reference is a DC voltage which is directly proportional to the desired load selected for the generating unit. The load section in the EG-A control box provides a DC voltage output which is directly proportional to the actual load provided by the generating unit. Output of the load section in the EG-A control box opposes the output of the adjustable load reference so that a "load error signal" is present unless the actual load provided by the generating unit is equal to the desired load selected for the generating unit. The load error signal is positive when output of the adjustable load reference is larger than the output of the load section. The load error signal is negative when output of the adjustable load reference is smaller than the output of the load section.

When the circuit breaker is closed, auxiliary contacts on the circuit breaker connect the "load error signal" to the input of the solid state switch, located in the automatic synchronizer section. If the load error signal is positive, the solid state switch operates to energize relay K2, closing the "raise" contact in series with the speed reference driving motor causing the driving motor to drive the speed reference control to a position that causes an increase in the output of the speed reference control. If the load error signal is negative, the solid state switch operates to energize relay K3, closing the "lower" contact in series with the speed reference driving motor causing the driving motor to drive the speed reference control to a position that causes a decrease in the output of the speed reference control.

Output of the speed reference control is fed to the speed reference section of the EG-A control box. Output of the speed reference section is "summed" with other signals in the EG-A control box, then amplified and applied to the EG-B10 hydraulic actuator transducer. With an increase in the output from the speed reference control, the EG-B10 hydraulic actuator operates to increase fuel supply to the engine, causing the generating unit to increase its load. With a decrease in output from the speed reference control the EG-B10 hydraulic actuator operates to decrease fuel supply to the engine, causing the generating unit to decrease its load. When actual load supplied by the generating unit is equal to the desired load selected for the generating unit the load error signal will be zero and no input will be provided to the solid state switch, relays K2 and K3 will be de-energized and the generating unit will operate with a constant load.

A change in the characteristics of the generating unit or a change in frequency of the infinite bus will result in a change of load on the generating unit. Any change of load on the generating unit results in a change in the output of the EG-A control box load section, producing a load error signal to the solid state switch. The solid state switch will then energize relay K2 or K3 and result in an increase or decrease of fuel to the engine until output of the EG-A control box load section is equal and opposite to the output of the load reference.

The load error signal to the solid state switch has a built in "dead band." This " dead band" is provided to reduce "hunting" of the load control circuit. The peaking gain control is provided to adjust the width of the dead band. The peaking gain control is normally adjusted to set the dead band as narrow as possible without "hunting."

EG-A CONTROL BOX

The EG-A control box provides signals to the electrically operated transducer, located in the hydraulic actuator. The transducer responds to the signals and controls the hydraulic actuator to maintain a constant, predetermined, engine speed. The EG-A control box receives speed reference signals and load reference signals from the peaking load control box. Current and voltage signals are provided by the generating unit.

The EG-A control box consists of a speed section, an amplifier section, and a load section. Refer to Fig. 2-11 and to the following paragraphs for description of the EG-A control box.

SPEED SECTION

The speed section compares the "reference speed" signal with the "true speed" signal and provides an output signal (speed error signal) that is proportional to the difference in true speed and reference speed. The speed error signal is "summed" with other signals in the EG-A control box, then amplified and applied to the transducer. The transducer operates to change engine speed, as necessary, to reduce speed error signal to zero.

The true speed section contains a frequency sensor and is connected, through a potential transformer, to the output of the generating unit. The output of the true speed section is a DC voltage that is directly proportional to the output frequency of the generating unit. Input to the reference speed section is supplied by the reference speed control located in the peaking load control box. Output of the reference speed section is a DC voltage that is directly proportional to the reference speed. Polarity of the reference speed section output signal is opposite to that of the true speed section output signal. The difference signal (speed error signal) is "summed" with the load section signal and applied to the amplifier section. The signal is amplified and applied to the transducer resulting in the necessary speed correction.

AMPLIFIER SECTION

The amplifier section consists of a solid state amplifier and a negative feedback stabilization section. The amplifier is provided to amplify the speed error signal to a magnitude sufficient to operate the transducer. The stabilizer section, consisting of a time delay negative feedback network, provides stabilization for the governor control system. The amplifier section contains "gain" and "stability" adjustment controls. Careful adjustment of these controls is mandatory for proper operation of the governor system, especially when operating generating units in parallel.

LOAD SECTION

The load section detects the magnitude, and phase relationship, of current and voltage in each phase of the generating unit. The load section then compensates for power factor and provides a DC voltage output (true load signal) that is proportional to the load supplied by the generating unit.

When operating in peaking mode, the true load signal is compared with the reference load signal. The difference between the true load signal and the reference load signal (load error signal) is applied as an input to the solid state switch, located in the synchronizer section of the peaking load control box. Output of the solid state switch operates relay K2 or K3 which results in an adjustment of the load supplied by the generating unit, as dictated by the peaking load control box adjustable load reference section. Refer to description of the adjustable load reference section, for a more detailed description of load correction.

When operating in dead line mode, the true load signal is applied through a paralleling network to all other generating units in the MU installation. The true load signal is also applied to the amplifier section which operates the transducer. The paralleling network is provided so that the EG-A amplifier section of each generating unit will receive the same true load signal. This common true load signal ensures isochronous control and proportional load sharing of the generating units.

ENGINE PROTECTIVE DEVICES

CRANKCASE PRESSURE DETECTOR, Fig. 2-12

The following paragraphs provide a brief description of the crankcase pressure detector. Refer to the Engine Maintenance Manual for detailed description.

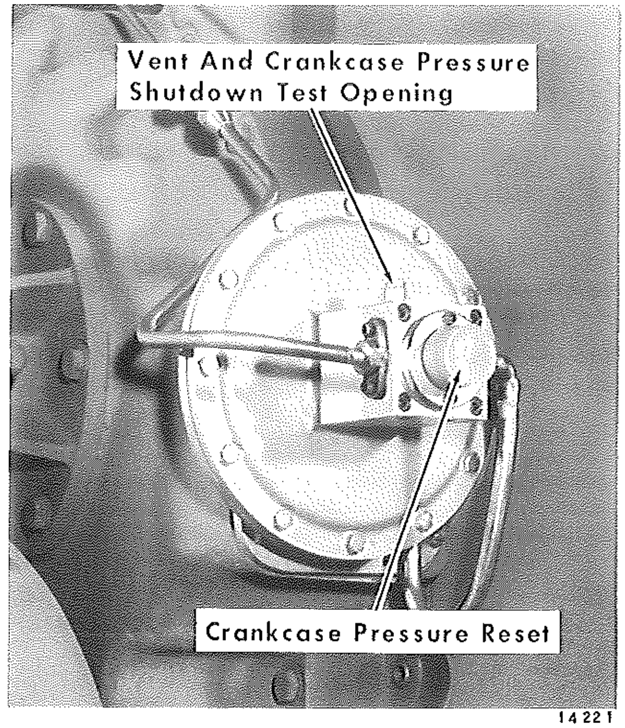


Fig. 2-12 — Crankcase Pressure Detector

The crankcase pressure detector protects the engine from damage resulting from any fault that causes positive pressure to build up in the crankcase. The crankcase pressure detector is mounted on the engine accessory drive gear housing. The sensing element and relief valve of the detector is connected between the crankcase and the lube oil monitor line, as shown in Fig. 2-6. When positive pressure is detected in the crankcase, the relief valve dumps oil from the lube oil monitor line into the crankcase and this low oil pressure is sensed by main bearing oil pressure switches MB1 and MB2. The low oil pressure operates MB1 and MB2 which energize the engine fault circuit and shut down the engine. When an engine shutdown occurs, due to positive crankcase pressure, the crankcase pressure reset button, Fig. 2-12, must be manually reset before the engine can be started. The reset button protrudes when the detector is tripped and is pressed in for normal operation.

Crankcase pressure shutdown should be verified periodically as indicated in the applicable Scheduled Maintenance Program. Proper operation can be verified by creating a suction on the vent tube at the top of the device, using a hydrometer bulb. The crankcase pressure detector should always be checked whenever an engine fault occurs.

ENGINE OVERSPEED TRIP, Fig. 2-13

The engine overspeed trip provides backup protection for the engine in case a fault develops in the engine speed governor. When an overspeed condition occurs, the engine overspeed trip operates to stop fuel injection, causing engine shutdown.

The engine overspeed trip is incorporated in the camshaft counterweight housing, located at the upper front portion of the engine. It consists of a flyweight held by a tension spring. When engine speed exceeds the set limit, spring tension is overcome by centrifugal force acting on the flyweight, permitting an outward movement of the flyweight which actuates a trip lever. This results in raising the injector rocker arm pawls which prevents fuel injection to the engine.

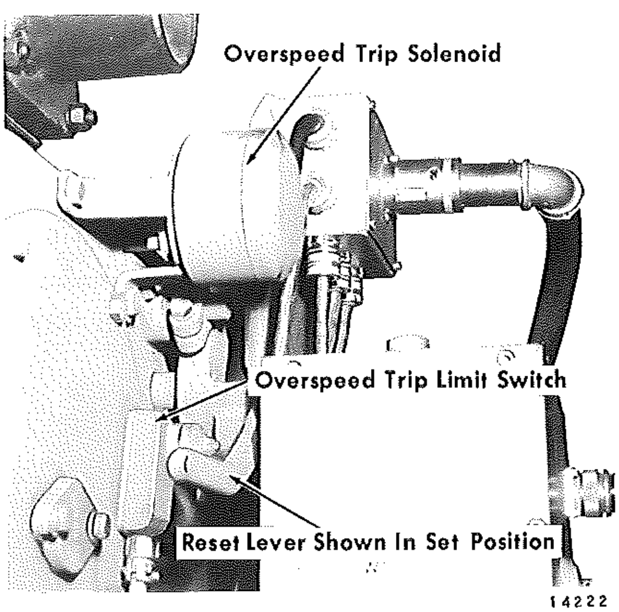


Fig. 2-13 — Engine Overspeed Trip

The engine overspeed trip may be actuated by the overspeed trip solenoid (OTS) as a result of system faults unrelated to engine speed. Any fault causing abnormal operation of the master relay, loading relay, or main circuit breaker auxiliary relay, will cause the overspeed trip solenoid (OTS) to become energized, actuating the engine overspeed trip and causing engine shutdown.

Operation of the engine overspeed trip closes the overspeed trip limit switch (OTLS). Closure of OTLS picks up the overspeed trip limit relay (OTL) which results in tripping the unit circuit breaker and providing an engine fault indication on the annunciator panel. To reset the engine overspeed trip, move the reset lever, Fig. 2-13, in a counterclockwise direction (to approximately the 9o'clock position) until it latches in the set position.

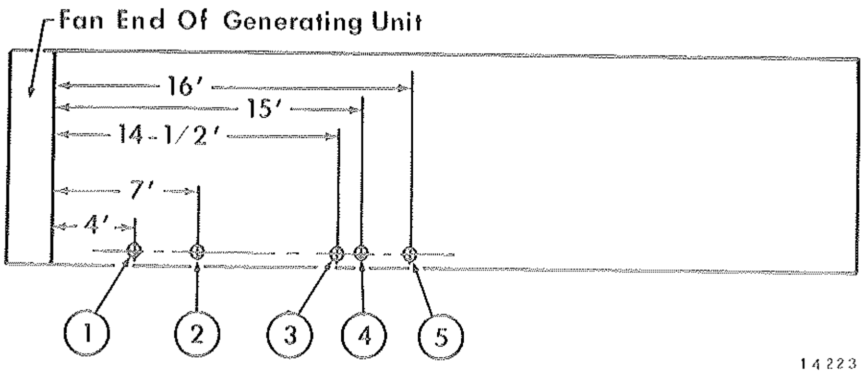
OTHER ENGINE PROTECTIVE DEVICES

Other engine protective devices include the low water pressure switch (LWS), main bearing relay (MBR), and main bearing oil pressure switches (MB1 and MB2). Refer to description of electrical devices, in another section of this manual, for description and operation of these protective devices.

SYSTEM DRAINS, Fig. 2-14

AIR BOX DRAINS

During normal operation, a small amount of engine oil will find its way into the airbox. This oil drains through tubes



*1. Fuel Oil Filter Drain
*2. Fuel Oil Filter Drip Pan Drain
3. Cooling System Drain
4. Manual Engine Air Box Drain
5. Engine Lube Oil Drain

*MPA unit only.

Fig. 2-14 — Table Of Engine Speed And Load Restrictions

leading to a cast block at the base of the accessory end of the engine. Piping, equipped with a tee, leads off the block. One end of the tee leads to a tube that carries the excess oil to the engine exhaust system where it is dissipated. The other end of the tee is piped to the outside of the generating unit and is terminated with a hand controlled drain valve, (4) Fig. 2-14.

A sample of the oil should be obtained periodically for inspection. Normally a small amount of black oil will be emitted when the drain valve is opened. If water is present in the sample, the engine should be locked out and carefully inspected for water leaks.

ENGINE LUBE OIL SUMP DRAIN, Fig. 2-14 And Fig. 2-6

Normal draining procedure is performed after the engine has run to warm and circulate the oil. The engine is then shut down, and oil drained from the engine by opening the drain valve shown in (5) Fig. 2-14 and Fig. 2-6. After at least one barrel of oil has been drained from the oil pan, the oil strainer drain valves, Fig. 2-8, are opened. Oil drains from the lube oil filters, from the cooler, and from the strainer into the sump.

COOLING SYSTEM DRAIN, Fig. 2-14 And Fig. 2-9

The cooling system drain (3) Fig. 2-14 and Fig. 2-9, will completely drain the cooling system.

The right bank water pump has a hole in the web to allow the pump housing to drain completely. No drain plug is needed.

FUEL OIL FILTER DRAINS, Fig. 2-14

Fuel oil filter drains are provided on the MPA generating unit. The drains, (1 and 2) Fig. 2-14, are used when changing fuel oil filters.

DIESEL ENGINE SPEED AND LOAD RESTRICTIONS

Certain precautions must be observed regarding high speed, no-load operation. If the diesel engine is allowed to run at high speed and light load or no load for any appreciable length of time, excess wear or failure of the turbocharger gear train can result, or objectionable oil "souping" or smoking can occur. To prevent undesirable operating conditions, observe speed-load restrictions shown in Fig. 2-15.

NOTE: The term "souping" is meant to indicate the accumulation of oily carbon in the exhaust system. The condition may occur during full speed low load operation.

AIR INTAKE FILTERS

GENERATING UNIT FILTERS, Fig. 2-16

The inertial air filter is built into the generator end of the unit and is located above the electrical control cabinet. It supplies filtered air for engine fuel combustion, generator cooling and cooling for electrical components within the electrical control cabinet. A drain is provided to dispose of any water that may accumulate at the base of the filter assembly.

Ambient air enters the generator compartment through the inertial air filters. The filters are made up of wedge shaped cells which have "U" shaped slots forming each wall of the wedge, see Fig. 2-16. The demands of devices that draw air from the compartment create a depression within the compartment, causing outside air to be drawn at high velocity through the wedge shaped cells. Dirt particles, because they are heavier than air, tend to travel in a straight line and are carried into a bleed duct located at the narrow end of the wedge. The main portion of the air, separated by

TABLE OF
ENGINE SPEED AND LOAD RESTRICTIONS

SPEED, RPM	LOAD, KW	TIME LIMIT OR OTHER CONSIDERATION
900 RPM - 2750 KW Peaking Rating 900 RPM - 2500 KW 8000 Hour Rating (Base Load)		
Idle	0	No restriction
900	0-500	Undesirable "souping" condition that should be held to a minimum.
900	2500	8000 Hrs./Year (Base Load) — See notes 1 & 2.
900	2750	2000 Hrs./Year (Peaking) — See notes 1 & 2.
750 RPM - 2100 KW Base Load		
Idle	0	No restriction
750	0-400	Undesirable "souping" condition that should be held to a minimum.
750	2100	8000 Hrs./Year (Base Load) — See Note 1.
750	2300	2000 Hrs./Year (Peaking) — See Note 1.

1. It is assumed that there will not be a combination of peaking operation and 2500 KW part load operation.
2. Minimum load restricted to 20% of the full load rating.

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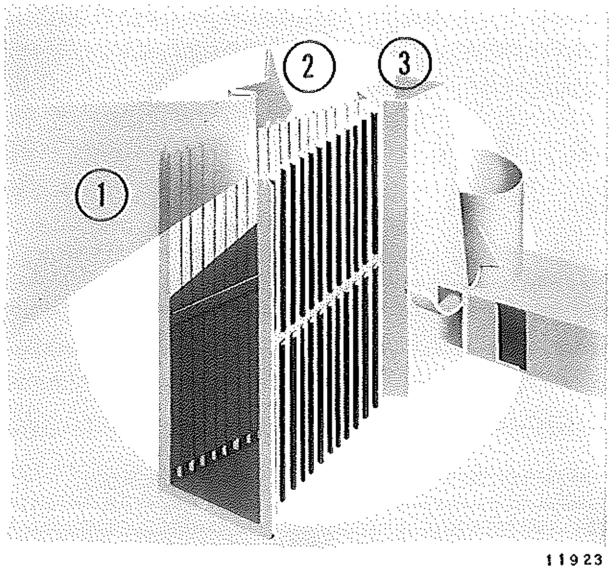
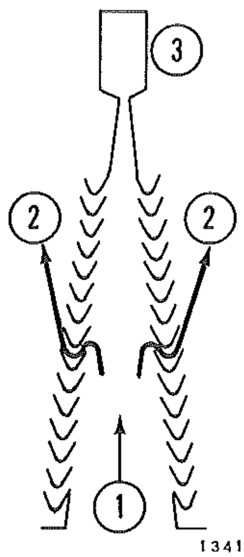
Fig. 2-15 — Table Of Engine Speed And Load Restrictions





1 - Outside Air Intake

2 - Clean Air Into Sealed Compartment

3 - Blower Driven Air Carrying Dirt

Fig. 2-16 — Inertial Air Filter Cell Diagram

the action of inertia from the dirt it carried, changes direction abruptly, passes through the narrow "U" shaped side passages, and enters the compartment as clean air. The bleed air containing dirt is drawn through an engine driven bleed blower and is expelled through the side of the generating unit.

ENGINE FILTER ASSEMBLY, Fig. 2-17

The filter assembly is composed of nine panel type oil bath filters, see Fig. 2-17.

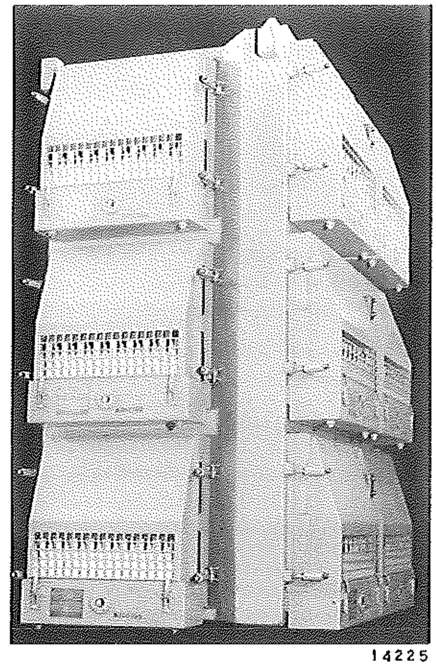


Fig. 2-17 — Panel Type Oil Bath Filters

Oil level and cleanliness should be checked periodically in accordance with the Scheduled Maintenance Program and Maintenance Instruction.

STATIC EXCITER, Fig. 2-18

The static exciter, consisting of rectifiers and saturable reactors with bias and control windings, furnishes DC voltage for excitation of the generator field.

Power input to the main windings of the static exciter is supplied from the control transformer, located in the auxiliary cubicle of the outdoor switchgear station. Output of the voltage regulator provides power to the bias and control windings. The static exciter is mounted near the roof, directly above the engine intake air filters, at the generator end of the generating unit. This location provides cooling for the rectifier elements by the engine intake air stream.

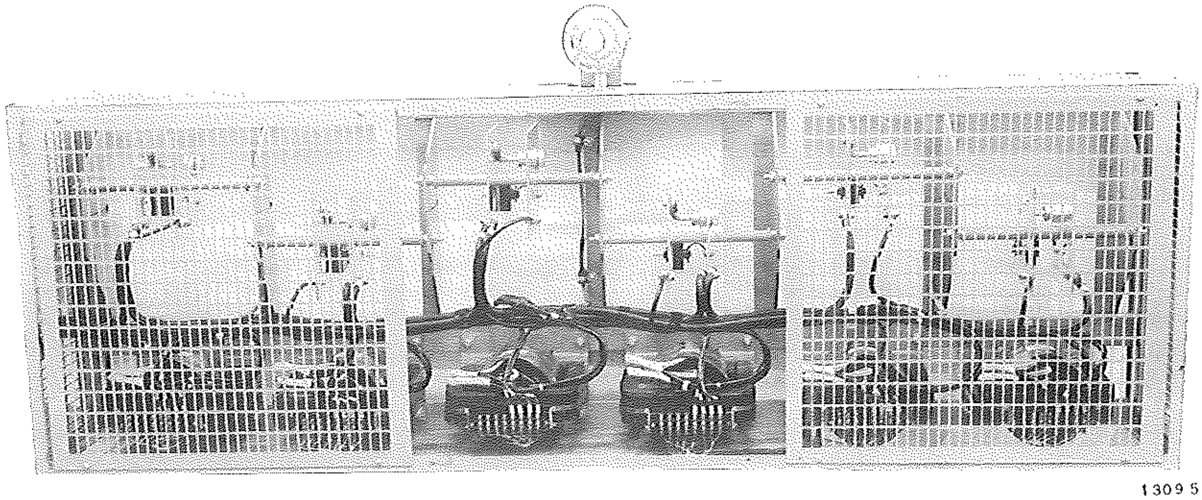


Fig. 2-18 — Static Exciter

ENGINE CONTROL CABINET, Fig. 2-19

The engine control cabinet is mounted on the accessory rack at the governor end of the engine. The controls and indicators visible from outside the cabinet consist of a lube oil pressure gauge, fuel oil pressure gauge, engine start switch, engine stop switch, immersion heater control and circulating pump motor switch, and a fuel oil transfer switch. The components inside the cabinet include lube oil pressure switches, low water pressure switch, fuel transfer relays, timer relay, and a rectifier.

The lube oil pressure gauge indicates pressure existing in the lube oil pressure monitor line, Fig. 2-6. The main bearing oil pressure switches, MB1 and MB2, are also connected to the lube oil pressure monitor line.

The fuel oil pressure gauge indicates existing fuel oil pressure between the engine mounted fuel pump and the double element engine mounted fuel filter, Fig. 2-4.

The engine start and engine stop push-button switches are provided for manual control of engine starting and stopping from within the generating unit enclosure.

The immersion heater control and circulating pump motor switch is used to apply power to the lube oil circulating pump motor and to energize the immersion heater control circuit. This switch is normally left in the on position.

The fuel oil transfer switch is supplied with MPA units only and is used to apply power to the fuel oil transfer control circuit.

Lube oil pressure switches, MB1 and MB2, are connected to the lube oil pressure monitor line. Pressure switch MB1 holds the diesel engine at idle speed until lube oil pressure increases to a predetermined value. Pressure switch MB2 initiates an engine shutdown, if lube oil pressure decreases below a predetermined value.

The low water pressure switch is connected to the right bank water pump outlet. The switch will provide an ENGINE fault indication and initiate engine shut down, if water pressure is not present within 45 seconds after the generator field is excited.

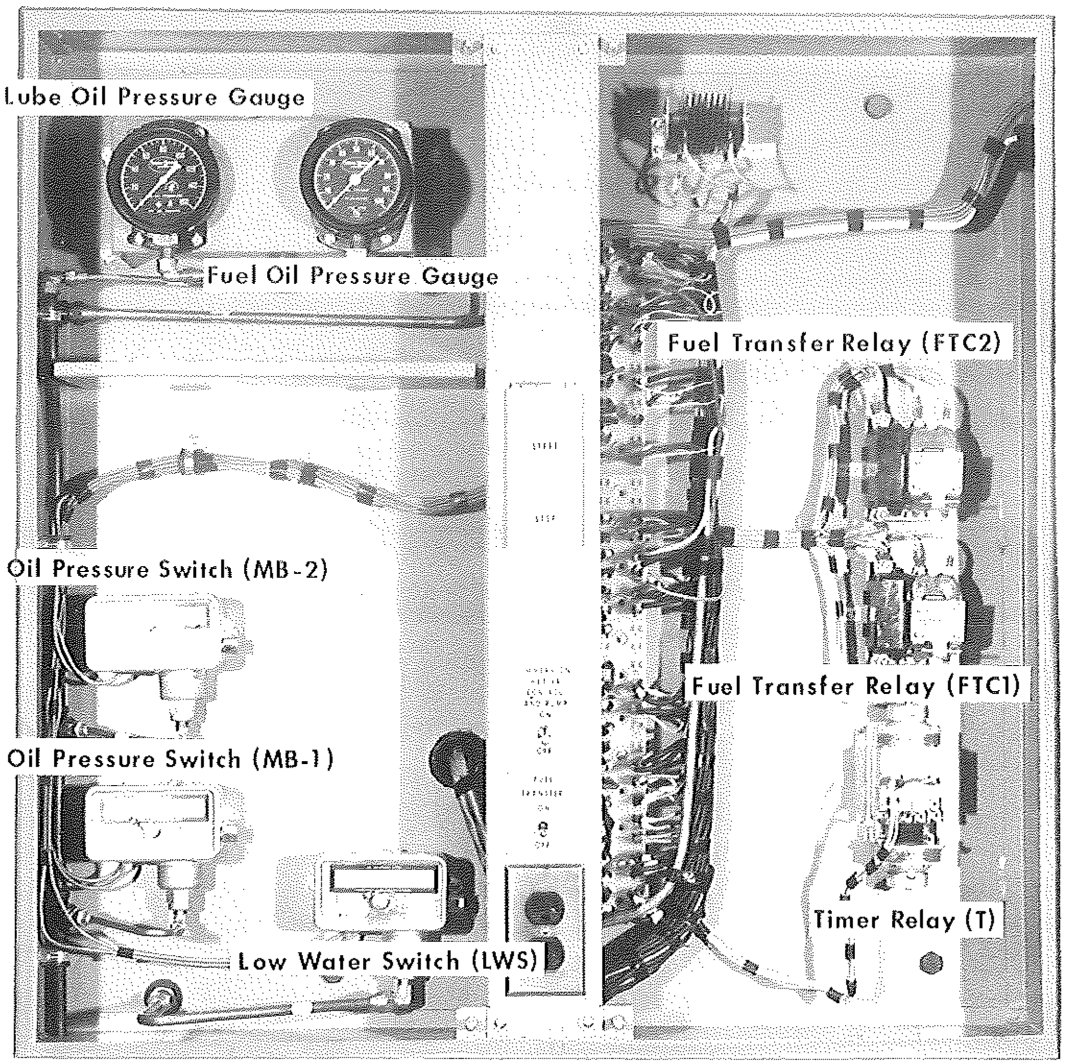


Fig. 2-19 — Engine Control Cabinet

The fuel oil transfer relays, FTC1 and FTC2, are supplied with MPA units only. When the fuel oil transfer switch is in the on position, operation of the relays are controlled by fuel transfer float switches, located in the fuel oil day tank of the MPA unit. FTC1 is controlled by the normal level fuel transfer switch FTS(N). FTC2 is controlled by the low level fuel transfer switch FTS(L). When energized the relays complete the power circuit to the fuel transfer pump motors. During normal operation only FTC1 will be energized.

The timer relay (T) is used to reduce over control of the shutters by applying current to TB for a specific length of time at timed intervals. Refer to description of the cooling system.

ENGINE STARTING MOTOR

Dual starting motors are used to crank the engine during starting. Each motor operates independently, being equipped with its own starting solenoid and pinion gear.

When the starting circuit is energized, a stepping switch steps from unit to unit at 1/4 second intervals seeking a unit that is ready to start. When a ready to start unit is found, a relay actuates to energize the starting motors for a 15 second (maximum) starting attempt. If the starter motor pinions do not engage with the ring gear within 2 seconds or if the engine does not start within 15 seconds, the stepping switch proceeds to the next ready to start unit. The stepping switch continues searching for ready to start units, bypassing the units that are running, until all units have started. If any unit fails to start after three attempts, the unit will be locked out. A motor relay is connected in a bridge circuit with the two starting motors. This relay interrupts the starting circuit, if one starting motor revolves faster than the other during a starting attempt. After an engine has started, a speed sensing device de-energizes the starting circuit.

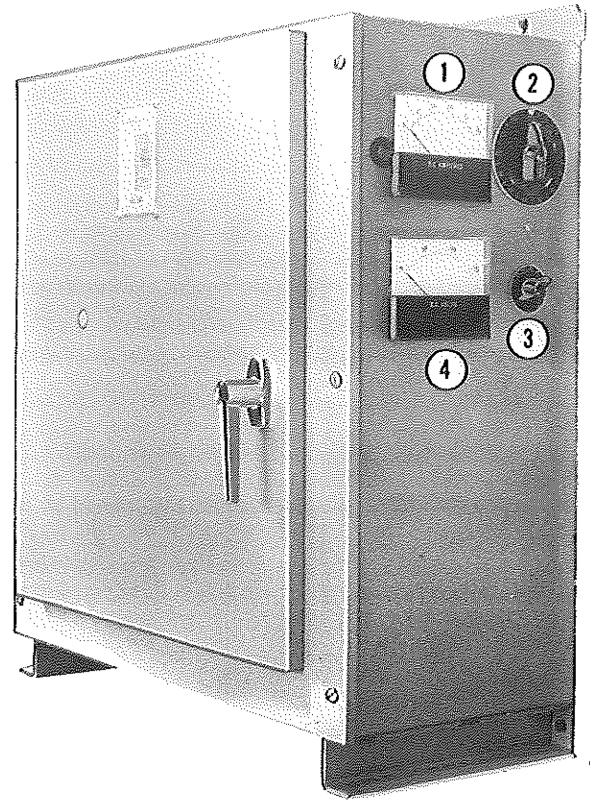
A heavy duty resistor is used to limit current to the starting motor during the first 4.2 seconds of cranking. The limited current prevents a build-up of momentum for the first revolution of the engine. During this first revolution, the engine will cease to rotate if a hydraulically locked piston is encountered. If the engine is free to rotate, full voltage is applied and fuel is injected into the cylinders.

Refer to the Engine Maintenance Manual for a more detailed description of the starting motors.

BATTERY CHARGER, Fig. 2-20

The battery charger is mounted in the MPA unit within the generator compartment and just below the dust bin blower discharge duct.

The battery charger is a completely automatic, solid state, constant voltage device having the following characteristics; AC voltage compensation, DC voltage regulation and current limiting, see Fig. 2-21.



1. Ammeter
2. Timer
3. Potentiometer
4. Voltmeter

Fig. 2-20 — Battery Charger

The transformer, saturable reactor, silicon rectifier stacks, and control unit are the four basic components of the charger. The transformer changes the incoming AC voltage to the required level to charge the battery and also isolates the incoming power from the output. The saturable reactor regulates the power output of the transformer continuously over the charge cycle. The rectifier stacks are made up of silicon diodes to change the secondary AC power to DC power. The control unit senses the condition of the battery and controls the reactor which in turn regulates the power output of the transformer. Power for charger operation is taken from the control power transformer, or from a separate station service supply. In case of an AC power failure a relay located within the charger is provided to disconnect the

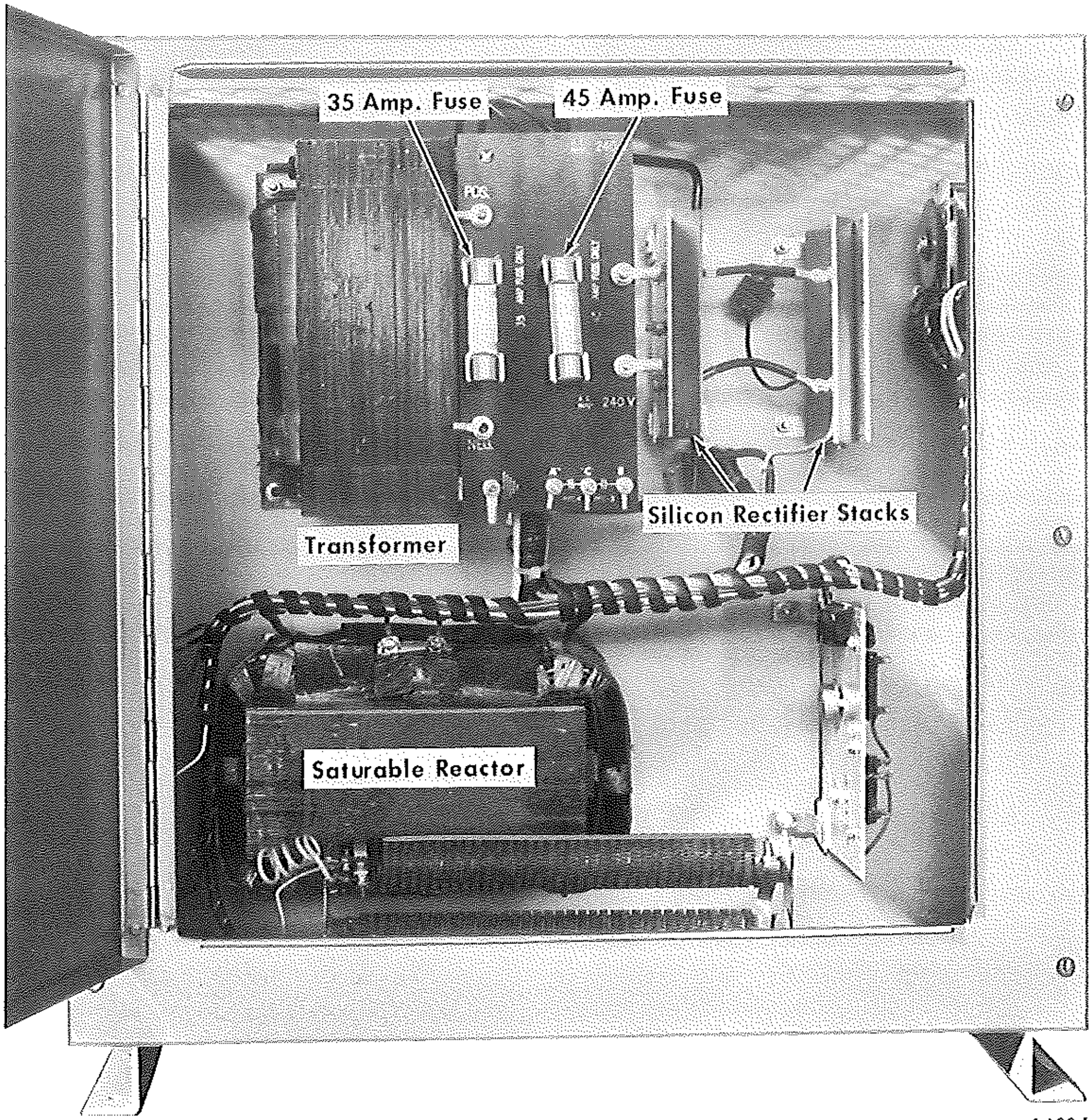


Fig. 2-21 — Inside View Of Battery Charger

automatic control from the battery and thereby eliminate any drain on the battery. One set of normally closed contacts on this relay is connected to terminals for connection to a remote power failure alarm. The charger will automatically resume charging upon return of AC power.

When a battery is discharged or standing idle its terminal voltage (approximately 112 volts DC) will be less than its on charge float or equalize voltage (131 volts DC). The charger will immediately begin to charge the battery at its rated output to 131 volts DC. When this voltage is reached the charge rate will begin to taper to a trickle charge just sufficient to maintain the battery voltage at 120 to 131 volts DC.

The charger will charge to its maximum current capacity (28 amps.) and begin to current limit if overloaded. The automatic current limiting feature limits the output of the charger to a maximum of 140% rated load, (chargers rated current capacity 20 amps.). The saturating current resistor is pre-set and factory adjusted to the required current limiting.

A potentiometer is provided to adjust the DC output so that the desired float voltage (127 volts DC) may be maintained. If the potentiometer does not give the required float point, the slider bands of the voltage divider located across the output terminals of the charger may be adjusted to give the required operating voltage. To give the batteries an equalizing charge, it is only necessary to set the timer control for any amount of time up to 24 hours. The rectifier will automatically hold the cell voltage (2.17 volts DC) at equalizing voltage (2.33 volts DC) for the pre-set time and will drop back to float voltage (127 volts DC) when the timer times out.

The AC input line is fused with a 45 amp, 250 volt fuse and the DC output line is fused with a 35 amp, 250 volt fuse.

The only battery charger maintenance required is an occasional blowing out of dust and tightening of connections.

The batteries are located on either side of the engine in compartments below the deck floor of the MPA unit. Refer to Fig. 2-1 for battery location.

ELECTRICAL CONTROL CABINET, Fig. 2-22 And Fig. 2-23

The electrical control cabinet contains electrical equipment for controlling the operation of the generating unit.

Mounted on a door of the cabinet is an elapsed time indicator, an annunciator panel, light switches, electrical receptacles, and a circuit breaker for the circulating pump motor. On MPA units a circuit breaker is also provided for the strip heater circuit. The annunciator panel contains five annunciator fault indicating lights and an annunciator reset pushbutton. On MPA units a sixth fault indicating light is provided for indicating fuel transfer faults.

Three or more control panels are mounted inside the cabinet. The starting control panel, sequence control panel, and the generator and governor control panel are installed in all electrical control cabinets. When deadline capability is requested, a deadline control panel is installed in the cabinet of each unit and an additional panel, the deadline sequence control panel, is installed in the cabinet of the MPA unit. Refer to the following paragraphs for a brief description of the panels.

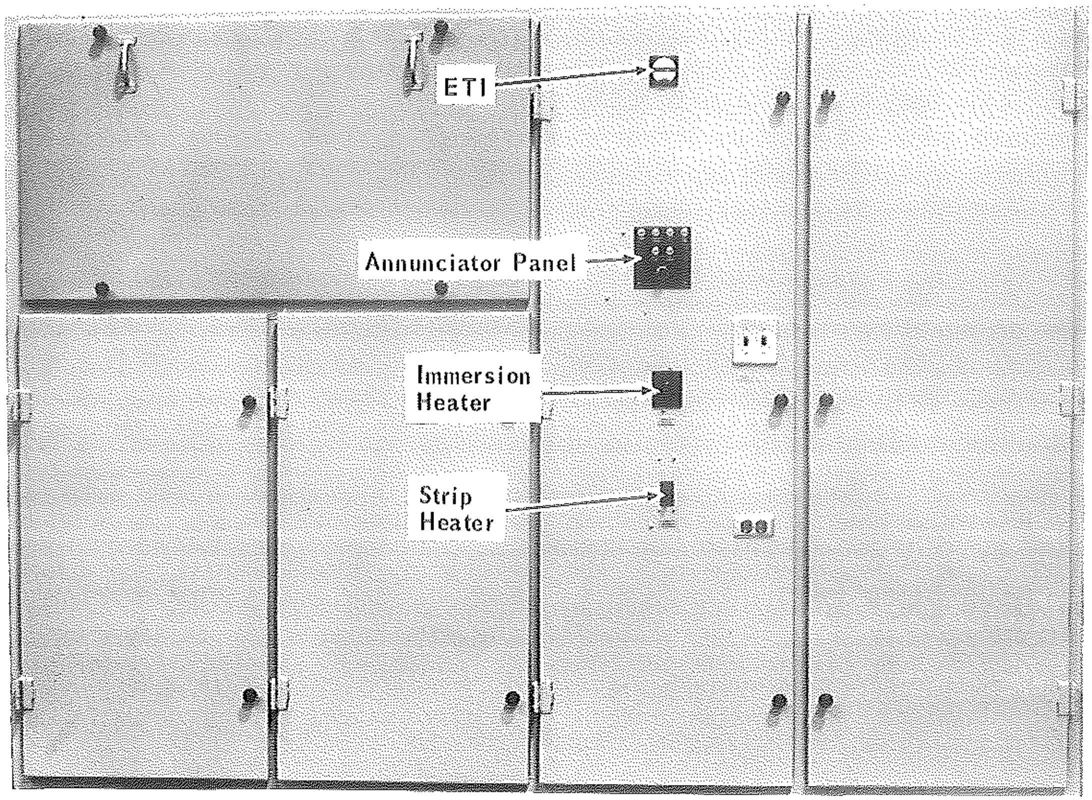


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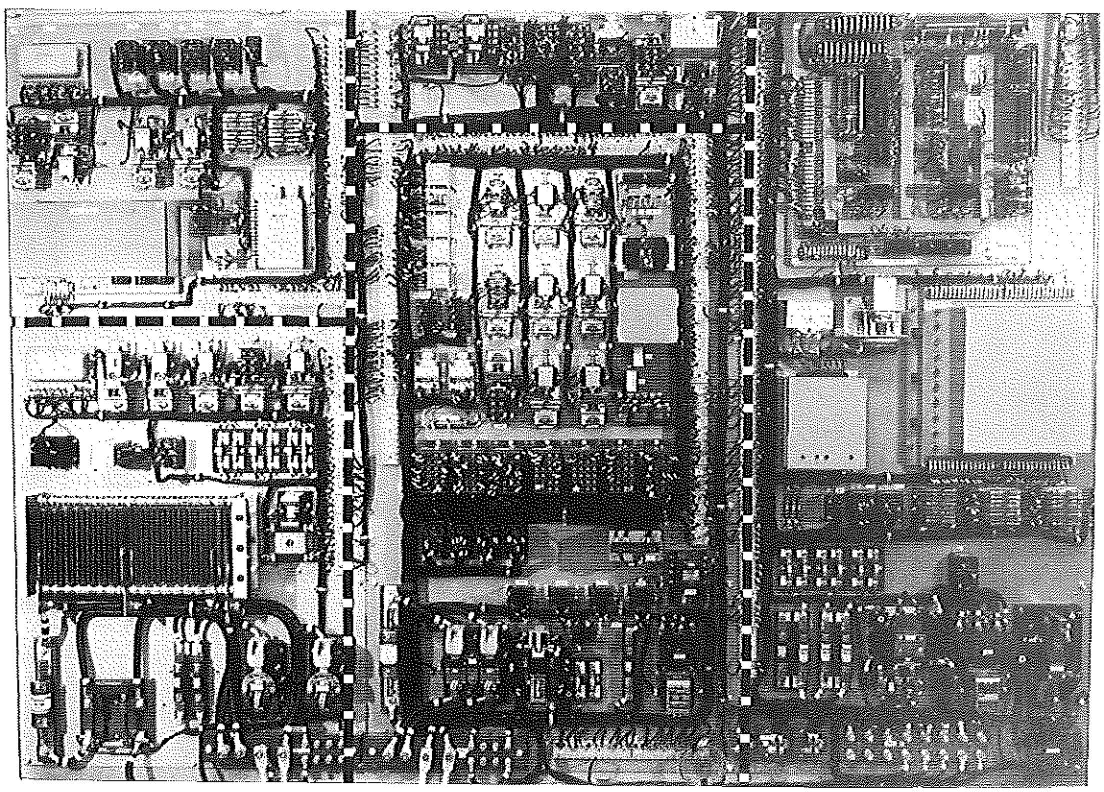
Fig. 2-22 — Electrical Control Cabinet — Exterior View

Deadline Sequence Control Panel   Deadline Control Panel



Starting Control Panel   Sequence Control Panel   Generator and Governor Control Panel

15121

Fig. 2-23 — Electrical Control Cabinet — Interior View

STARTING CONTROL PANEL, Fig. 2-24

The equipment on the starting control panel is used for starting the diesel engine. The equipment includes the starting resistor (RE-ST), the starting stepping switch (STS), and various relays and fuses. Refer to description of electrical devices, in a later section of this manual, for description of the equipment located on this panel.

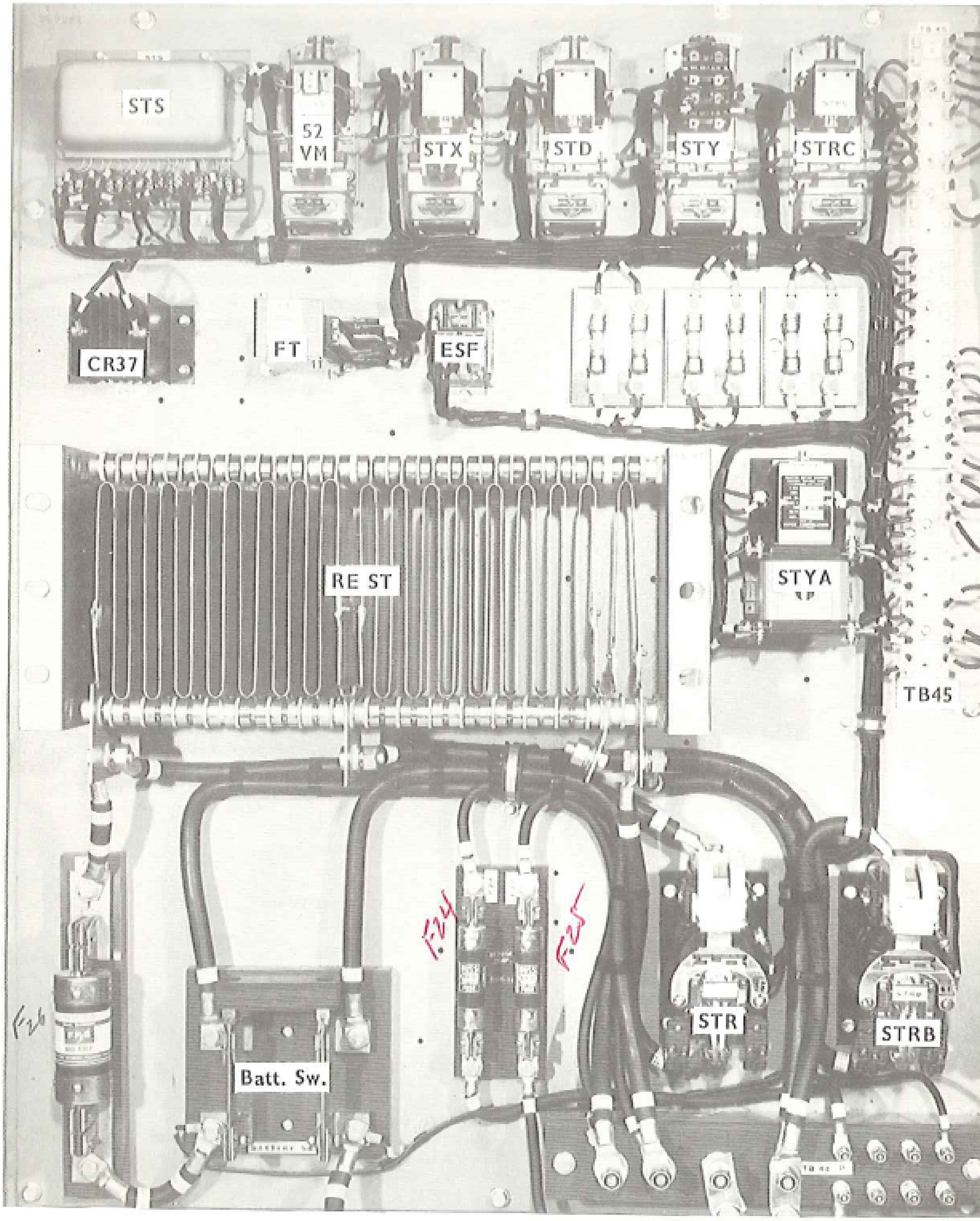


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Fig. 2-24 — Starting Control Panel

SEQUENCE CONTROL PANEL, Fig. 2-25

The equipment on the sequence control panel controls the sequence of operation during start up and shut down of the generating unit. The equipment includes the starting contactor, field flashing contactor, field flashing cutout relay, speed sensing panel, and various other relays and contactors. Refer to description of electrical devices, in a later section of this manual, for description of the equipment located on this panel.

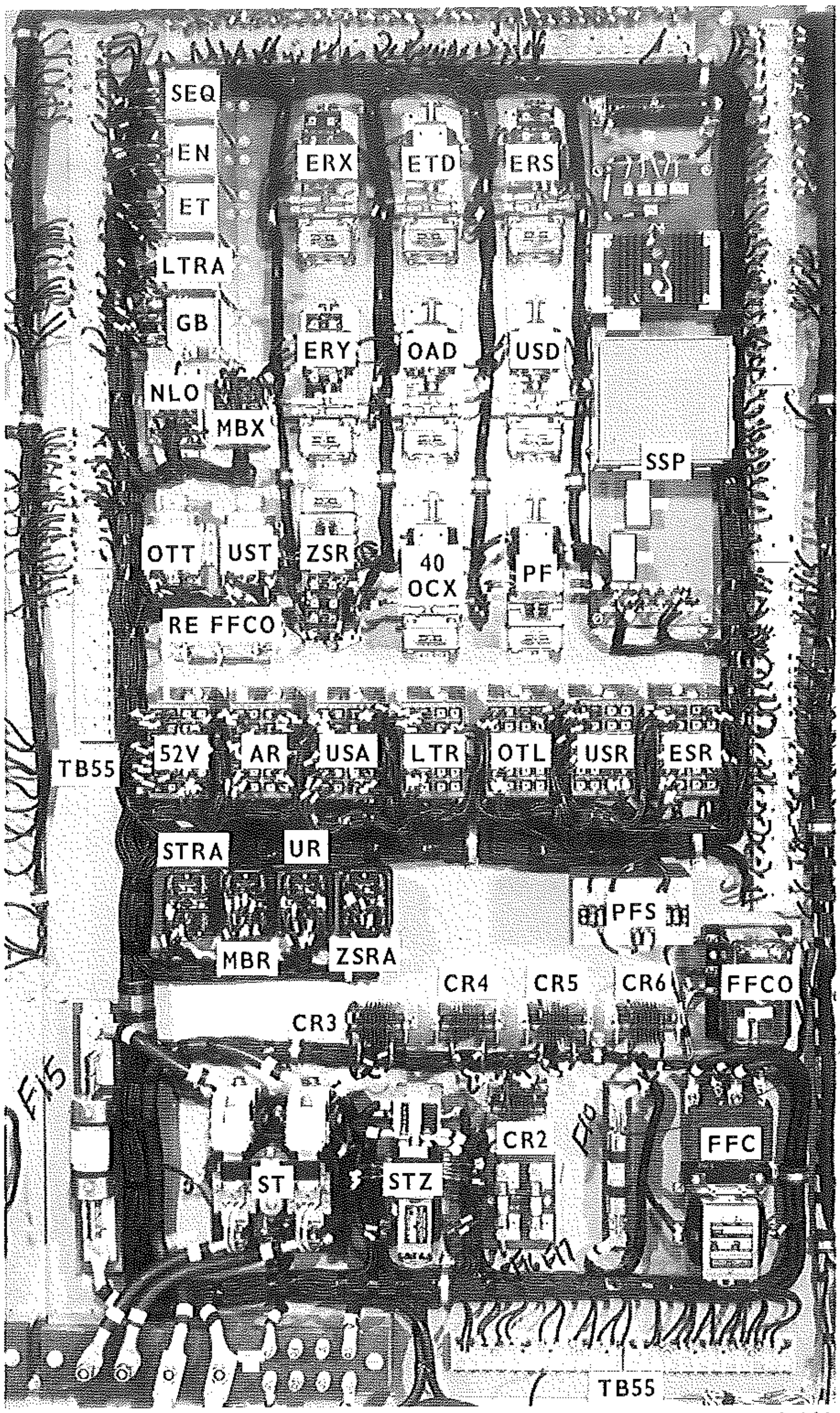

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Fig. 2-25 — Sequence Control Panel

GENERATOR AND GOVERNOR CONTROL PANEL, Fig. 2-26

The equipment on the generator and governor control panel controls output voltage and frequency of the generating unit. The equipment includes the static voltage regulator, peaking load control box, EG-A control box, exciter contactor, and various fuses and relays. Refer to description of electrical devices, in a later section of this manual, for description of the equipment located on this panel.

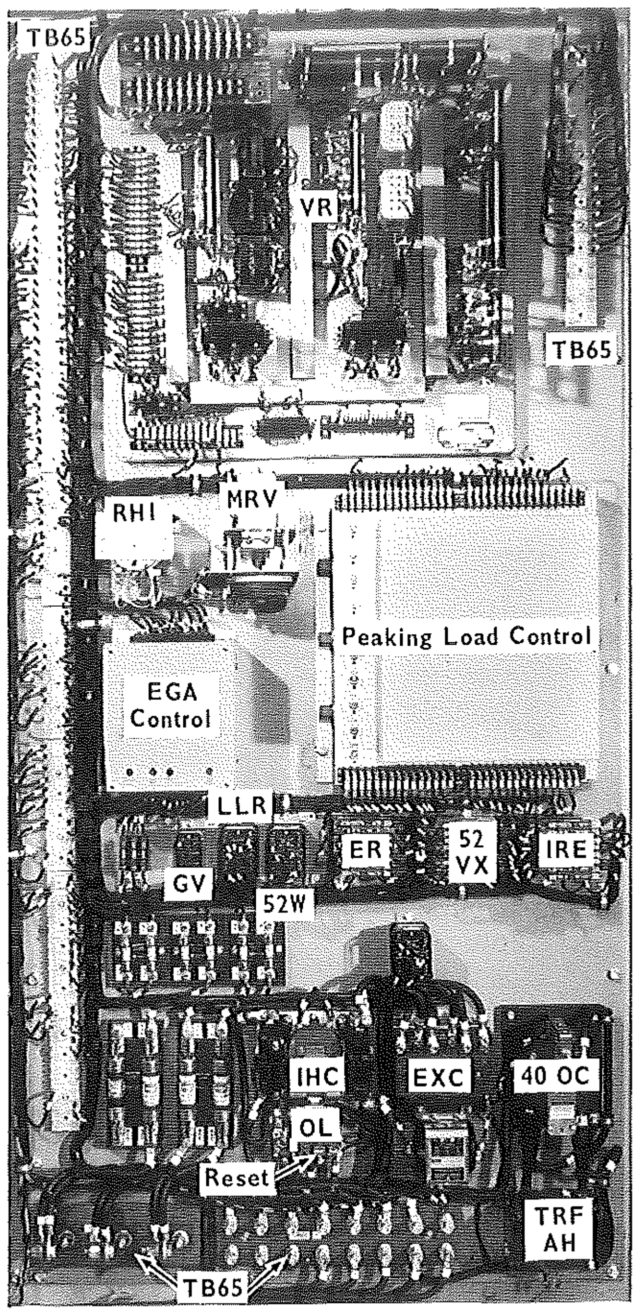

Fig. 2-26 — Generator And Governor Control Panel

DEADLINE SEQUENCE CONTROL PANEL, Fig. 2-27

The electrical control cabinet is equipped with a deadline sequence control panel only when deadline mode of operation is requested. The deadline sequence panel is supplied only with the electrical control cabinet of the MPA unit.

The equipment located on the deadline sequence control panel includes the deadline stepping switch relay (DLS), rectifiers, and various other relays. A KW limiter and a motor driven rheostat are included on the panel, if the MU installation is equipped for automatic deadload pickup. The KW limiter and motor driven rheostat prevent repeated attempts of the MU installation to pick up a deadload requiring more KW than the MU installation can supply. Refer to description of electrical devices, in a later section of this manual, for description of the equipment located on this panel.

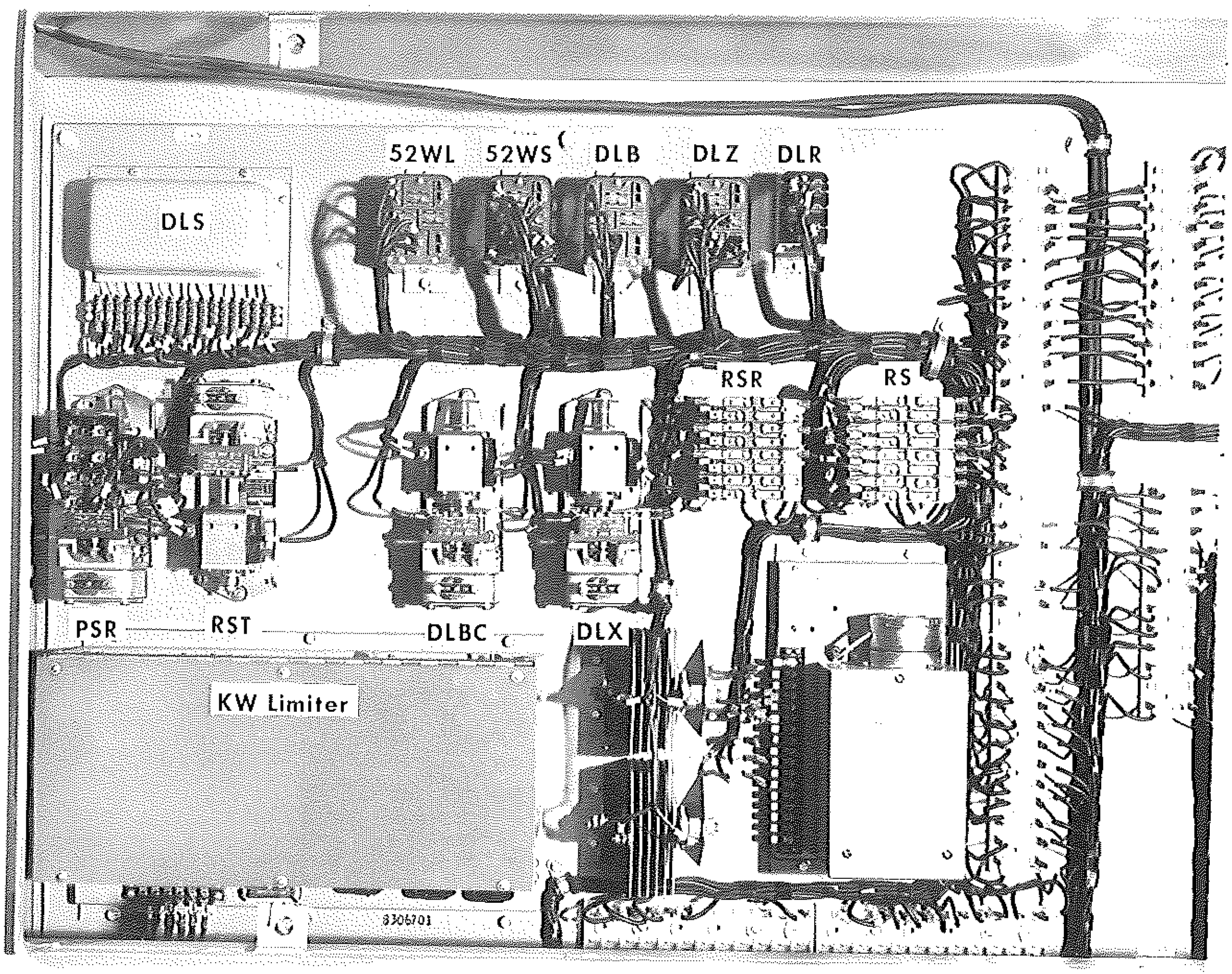

Fig. 2-27 — Deadline Sequence Control Panel

DEADLINE CONTROL PANEL, Fig. 2-28

The electrical equipment cabinet of each generating unit is equipped with a deadline control panel when this mode of operation is requested. The various relays and rectifiers located on the deadline control panel operate to control the unit when in deadline mode of operation. Refer to description of electrical devices, in a later section of this manual, for description of the equipment located on this panel.

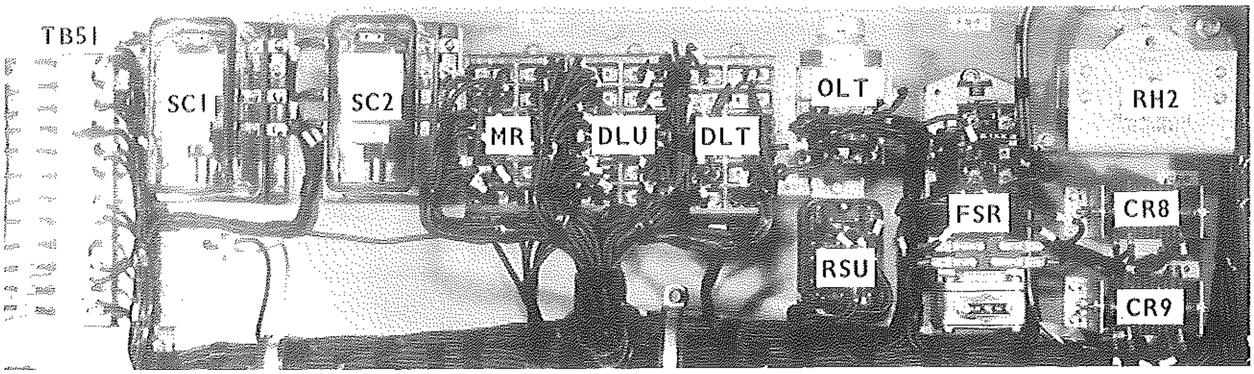

Fig. 2-28 — Deadline Control Panel

SECTION 3

OUTDOOR SWITCHGEAR STATION

GENERAL

The outdoor switchgear station, Fig. 3-1, is a sectionalized all steel weatherproof enclosure which contains all equipment necessary for manual or automatic operation of the MU type power plant.

The outdoor switchgear station contains one auxiliary switchgear cubicle that is common to all generating units in the MU installation. It also contains one generator switchgear cubicle for each generating unit in the MU installation. Removable panels are provided at the rear of the enclosure for access when making electrical connections between the generating units and the switchgear equipment. A service aisle is provided for operating, servicing, and maintenance of the equipment.

A partial interior view of a typical enclosure, Fig. 3-2, shows the front panel of the auxiliary switchgear cubicle and the

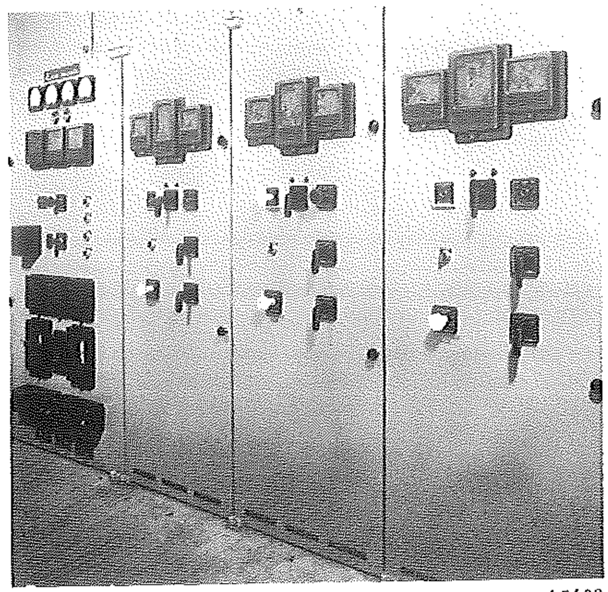

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Fig. 3-2 — Typical Outdoor Switchgear Station — Partial Interior View

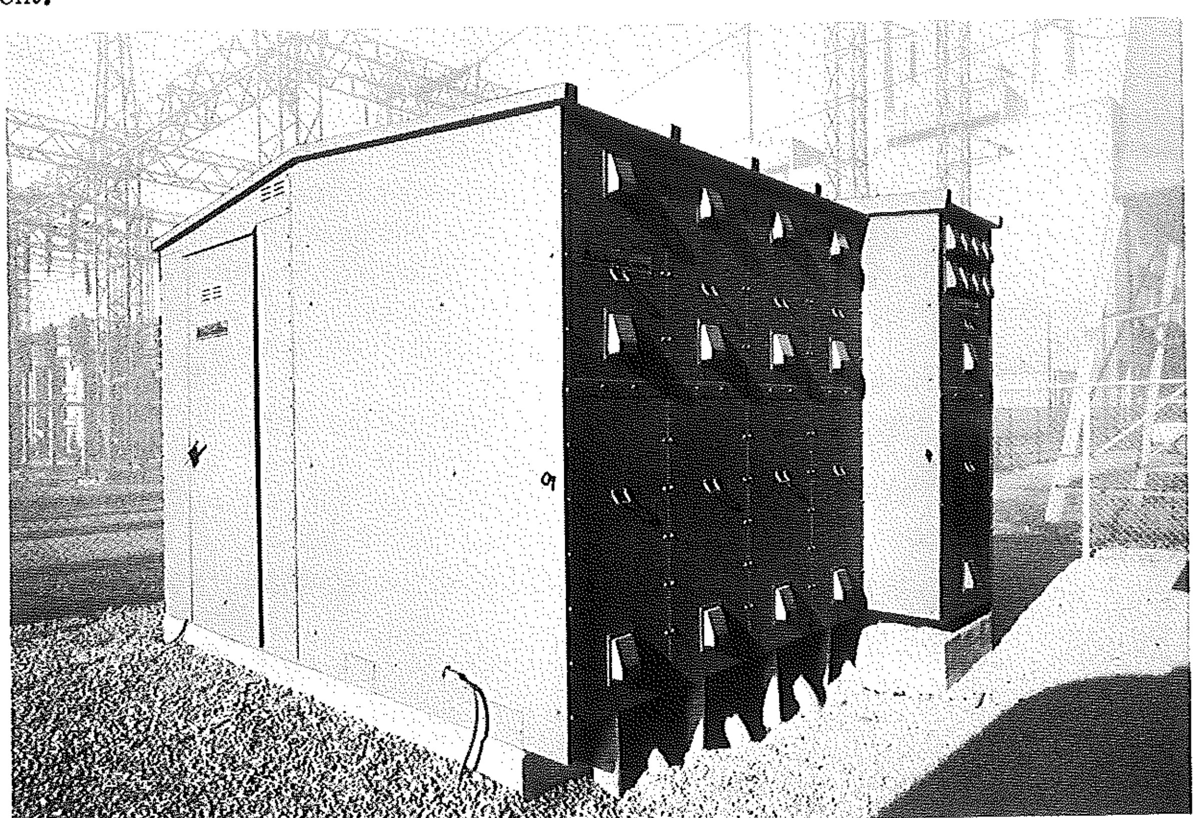

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Fig. 3-1 — Typical Outdoor Switchgear Station front panels of three generator switchgear cubicles. Some items shown on the front panels are optional extra items and are not necessarily supplied with each installation. Compartments located above the cubicles contain potential transformers and plant control relays.

A strip heater rated at 500 watts is located in the auxiliary switchgear cubicle and in each of the generator switchgear cubicles. The heater prevents condensation and maintains the high dielectric strength of the insulation. A thermostat, located in each cubicle, turns the heater on and off as necessary to maintain a predetermined temperature.

An optional remote control station, which provides for automatic control as well as manual operation of the MU type power plant, can be supplied upon request from the customer.

AUXILIARY SWITCHGEAR CUBICLE

The components contained in the auxiliary switchgear cubicle perform functions that are common to all generating units in the MU installation. These components include a control power transformer, meters, indicators, protective relays, fuses, and operating controls.

Meters, indicators, protective relays, and operating controls are located on the front panel of the auxiliary switchgear cubicle, Figs. 3-3 and 3-4. The index numbers of the components have been arranged so that a component has the same index number in both figures. Two additional components that are not visible from the panel front are shown in Fig. 3-4. Refer to Fig. 3-5 for nomenclature and purpose of the components located on the front panel. Some of the components located on the front panel are optional items which are not supplied with all installations.

An interior view of the auxiliary switchgear cubicle is shown in Fig. 3-6. Some components inside the cubicle are visible when the front panel is opened, other components are located inside compartments of the cubicle and are not visible without removing panels from the compartments. Refer to Fig. 3-7 for nomenclature and purpose of the components located inside the auxiliary switchgear cubicle.

The circuit breaker, connected in the secondary side of the control power transformer, is provided with a lock and key. The key can be removed only when the circuit breaker is in the OFF position. The key may then be used to unlock the pivoted carriage holding the control power transformer fuses. Opening the circuit breaker removes all load from the control power transformer. However, the control power transformer is still energized through the high voltage fuses.

The auxiliary switchgear cubicle shown in this section is used on a typical MU4 installation. The arrangement of components inside the cubicle may be slightly different for other MU installations.

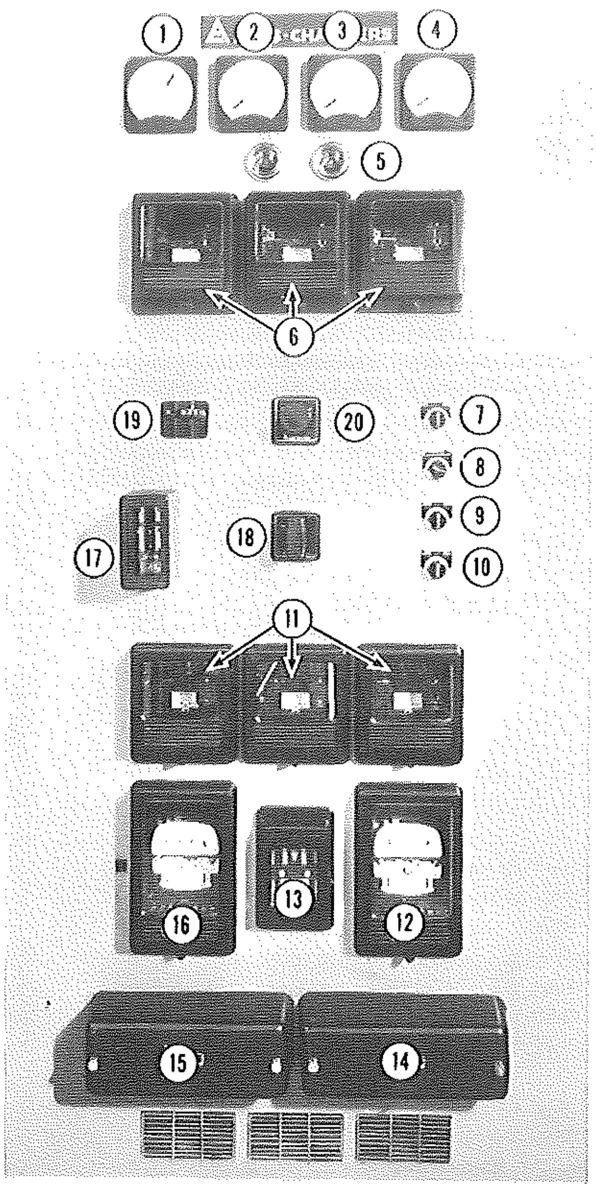

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Fig. 3-3 — Auxiliary Switchgear
Cubicle — Front Panel

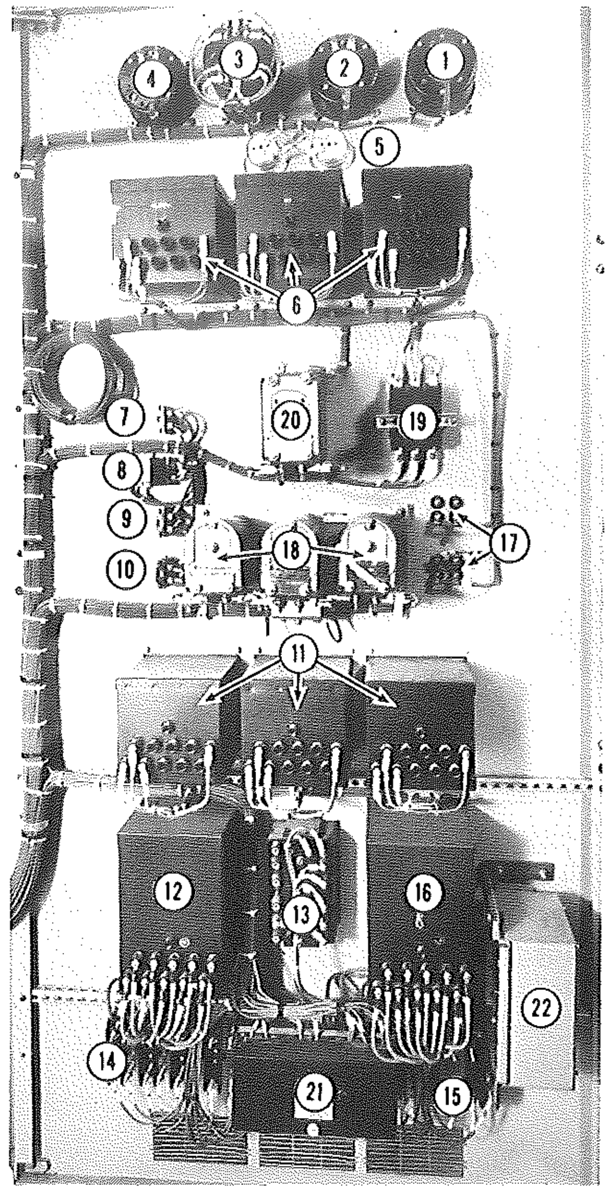

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Fig. 3-4 — Auxiliary Switchgear
Cubicle — Front Panel, Rear

Index Number	Nomenclature	Purpose
1	Frequency Meter	Indicates frequency of bus or generating unit as selected by BUS-GEN volts-frequency selector, located on front panel of generator switchgear cubicle.
2	AC Voltmeter	Indicates voltage of bus or generating unit as selected by BUS-GEN volts-frequency selector, located on front panel of generator switchgear unit.
3	KILOWATT-VAR Meter	Indicates kilowatts or vars of generating unit. Phase A, B, or C is selected by AMMETER-WATTMETER-VARMETER selector, located on front panel of generator switchgear cubicle. Kilowatts or Vars are selected by KILOWATT-VARS selector (item 20), located on auxiliary switchgear cubicle.
4	AC Ammeter	Indicates AC amperes of phase A, B, or C of generating unit as selected by AMMETER-WATTMETER-VARMETER selector, located on generator switchgear cubicle.
5	SYNCHRONIZING LIGHTS	Used to determine when generating unit is synchronized with bus. When synchronizing, generator and bus is synchronized when both lamps are dark.
6	Relay 87 (Differential Current Relay)	Used to protect high voltage circuit of generating unit from short circuit between phases and between phase and ground. If a short circuit develops, relay 87 operates to energize relay 86, which results in shut down of the MU plant.
7	MU Plant START-STOP Selector	Used to issue a plant start or stop signal. The signal is issued simultaneously to all generating units in the MU installation.
8	PEAKING-TRANSFER-DEADLINE Selector (PTD)	Used to select the desired mode of operation for the MU plant.

Fig. 3-5 — Index Number, Nomenclature, And Purpose Of Components Located On Front Panel Of Auxiliary Switchgear Cubicle (Sheet 1 of 2)

Index Number	Nomenclature	Purpose
9	GOVERNOR CONTROL Selector	Used to raise or lower the frequency or kilowatt output of the MU installation.
10	VOLTAGE CONTROL Selector	Used to raise or lower the voltage output of the MU installation.
11	Relay 27 (Low Voltage Relay)	Issues a circuit breaker trip signal, if voltage decreases to less than approximately 87.5% of rated voltage.
12	Kilowatt Hour Meter	Indicates Kilowatt hours supplied by the MU installation.
13	Auxiliary Kilowatt Hour Meter Relay (This is an optional extra item and is not used on all installations)	Disconnects auxiliary kilowatt hour meter (item 16) when one or more MP generating units are connected to the MU bus.
14	This item is an optional extra installed by the customer.	
15	This item is an optional extra installed by the customer	
16	AUXILIARY KILOWATT HOUR METER (This is an optional extra and is not used on all installations)	Indicates kilowatt hours supplied to the MU installation from system power. This includes power for operating the battery charger and the immersion heater.
17	This item is an optional extra installed by the customer	
18	Relay 86 (LOCKOUT RELAY)	Initiates a normal shutdown sequence and locks out all unit circuit breakers when a fault is sensed by low voltage relay 27 (item 11) or differential current relay 87 (item 6). When relay 86 is tripped, the annunciator RESET pushbutton must be pressed and the lockout relay 86 must be reset before normal operation can be resumed.
19	Heater, Lights, and Receptacles Switch	Controls power to space heater, switchgear lighting, and utility receptacles.
20	KILOWATT-VARS Selector	Selects kilowatts or vars to be indicated on the KILOWATT-VAR meter (item 3).
21	Phase Shifting Transformer	Used to shift the phase of the voltage 90° so that VARS can be indicated by the KILOWATT-VARS meter.
22	Transducer	Converts AC to DC for operation of the frequency meter. Magnitude of the DC output from the transducer is directly proportional to the frequency of the AC input.

Fig. 3-5 — Index Number, Nomenclature, And Purpose Of Components Located On Front Panel Of Auxiliary Switchgear Cubicle (Sheet 2 of 2)

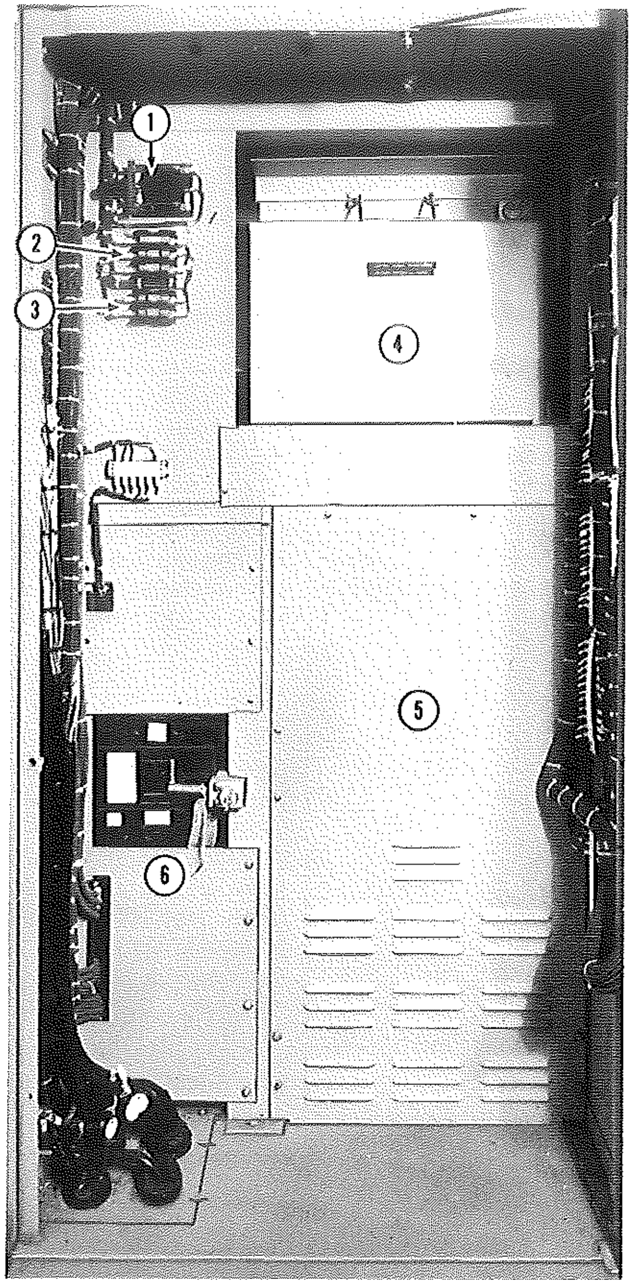


Fig. 3-6 — Auxiliary Switchgear
Cubicle — Interior View

Index Number	Nomenclature	Purpose
1	Switch (DC Control)	Controls DC power in the auxiliary switchgear cubicle.
2	Fuses (3) (Secondary Bus)	
3	Fuses (2) (DC power to cutout relay for auxiliary power kilowatt hour meter, 16, Fig. 3-3) (This is an optional extra and is not used on most installations)	Provides protection for cutout relay.
4	Fuse compartment for control power transformer fuses	Provides protection in primary circuit of the control power transformer.
5	Control Power Transformer Compartment	The control power transformer provides power to the MU installation for the battery charger, immersion heater, fuel oil transfer pumps, static exciter, and control circuits. When one or more MP generating units are operating, the control power transformer is excited from the MU plant. During shutdown of the MU plant, the control power transformer is excited from system power.
6	Circuit Breaker For Control Power Transformer	Provides protection in secondary circuit of the control power transformer.

Fig. 3-7 — Index Number, Nomenclature And Purpose Of Components Located Inside The Auxiliary Switchgear Cubicle

GENERATOR SWITCHGEAR CUBICLE

A generator switchgear cubicle is required for each generating unit in the MU installation. The components contained in the cubicle perform functions related to the corresponding generating unit. The components include indicators, relays, operating controls, and a unit circuit breaker.

Indicators, relays, and operating controls are located on the front panel of the generator switchgear cubicle, Fig. 3-8 and 3-9. The index numbers of the components have been arranged so that a component has the same index number in both figures. An interior view of the cubicle, with the unit circuit breaker installed, is also shown in Fig. 3-9. Refer to Fig. 3-10 for nomenclature and purpose of the components located on the front panel.

The AMMETER-WATTMETER-VARMETER selector and the BUS-GEN (volts-frequency) selector are equipped with removable handles. The removable handles with key shaft prevents operation of the controls by unauthorized personnel or simultaneous operation of more than one switch controlling the same circuit. Handles can be inserted or removed only when the switches are in the OFF position.

The unit circuit breaker is an Air Magnetic Circuit Breaker, Type MA-250 or MA-350. Procedures for withdrawing and inserting the unit circuit breaker are given in the following paragraphs.

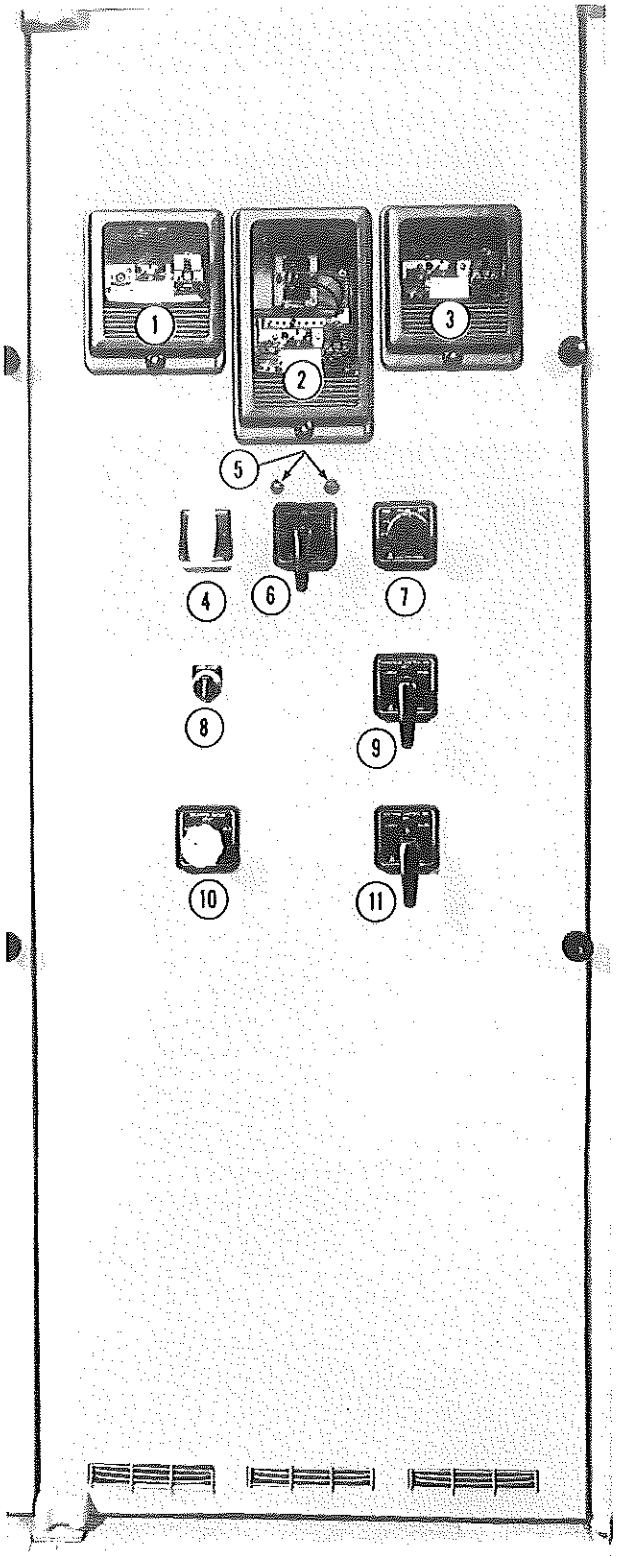


Fig. 3-8 — Generator Switchgear Cubicle — Front Panel

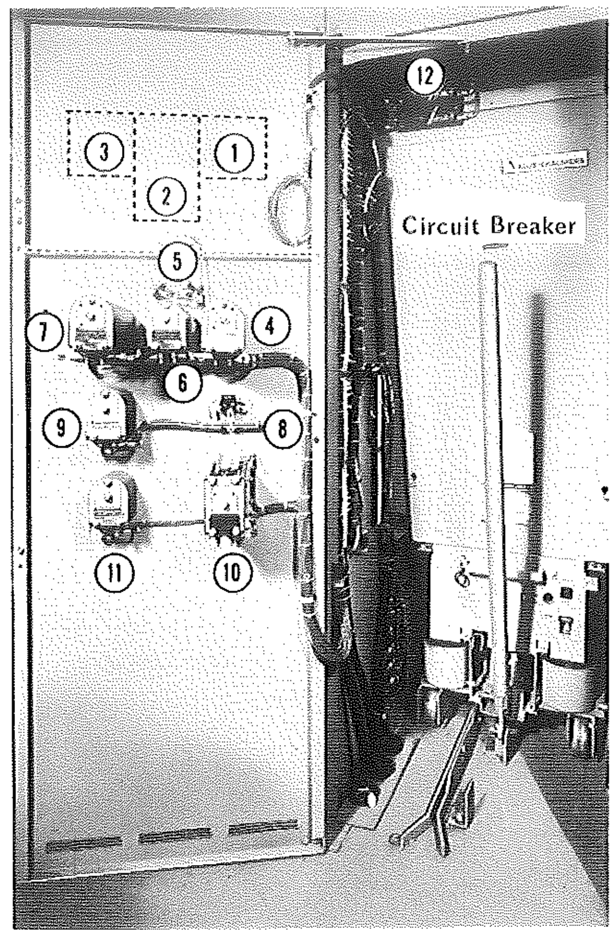


Fig. 3-9 — Generator Switchgear Cubicle With Front Panel Open (Showing Circuit Breaker With Handle Attached)

Index Number	Nomenclature	Purpose
1	Relay 59 (OVERVOLTAGE RELAY)	Initiates unit shutdown and issues a SEQUENCE fault indication when an overvoltage condition is detected. The fault must be corrected and the annunciator RESET pushbutton pressed before normal operation can be resumed.
2	Relay 67 (REVERSE POWER RELAY)	Initiates unit shutdown and issues a breaker fault (GB) indication when a reverse power condition is detected. The fault must be corrected and the annunciator RESET pushbutton pressed before normal operation can be resumed.
3	Relay 55 (LEADING VARS RELAY)	Initiates unit shutdown and issues a breaker fault (GB) indication when the generator field excitation is reduced causing the generator to draw a high component of reactive power in order to remain in-step with the system. The fault must be corrected and the annunciator RESET pushbutton pressed before normal operation can be resumed.
4	AMMETER-WATTMETER-VARMETER Selector	Used to connect phase A, B, or C of generating unit to AC ammeter and to kilowatt-var meter, located on front panel of auxiliary switchgear cubicle.
5	Circuit Breaker Indicator Lights	Indicates position of circuit breaker. Red light indicates circuit breaker is closed. Green light indicates circuit breaker is tripped to open position.
6	CIRCUIT BREAKER Selector	Used to trip or close generating unit circuit breaker.
7	BUS-GEN (Volts-Frequency) Selector	Connects phase A, B, or C of bus or generating unit to voltmeter and frequency meter, located on auxiliary switchgear cubicle.
8	STOP-START Selector	Used to issue a stop or start signal to the generating unit.
9	GOVERNOR CONTROL Selector	Used to raise or lower frequency or kilowatts of the generating unit.
10	MANUAL SELECTOR	Used to select manual or automatic control of the generating unit.
11	VOLTAGE CONTROL Selector	Used to raise or lower output voltage of the generating unit.
12	Breaker Knife Switch And Fuses	Controls power to circuit breaker control circuit.

Fig. 3-10 — Index Number, Nomenclature, And Purpose Of Components Located On Front Panel Of Generator Switchgear Cubicle

AIR MAGNETIC CIRCUIT BREAKERS TYPES MA-250 AND MA-350 MP45 POWER PLANTS

Successful functioning of the power plant and operator safety depends upon proper operation of the circuit breakers. Regular, systematic, and thorough inspection and maintenance is necessary to ensure proper operation. When performing inspection and maintenance procedures it will be necessary to withdraw the circuit breakers from the generator switchgear cubicles. The following procedures are recommended for withdrawal and insertion of the circuit breakers.

WARNING: To prevent possible injury to personnel and damage to equipment, open circuit breaker by pushing the PUSH TO TRIP rod (3), Figs. 3-11 and 3-12, before performing withdrawal or insertion procedures. Do not pull PULL TO CLOSE BREAKER ring (4), Figs. 3-11 and 3-12 before performing removal or installation procedures.

The breaker knife switch should be left closed to provide safety trip power.

WITHDRAWING BREAKER, Figs. 3-11 AND 3-12

1. Open the breaker by pushing the manual trip rod (3), or by energizing the trip circuit with the circuit breaker control switch on the front panel. (Depressing the breaker release will also automatically trip the breaker, however either of the above two methods is preferred.)

   Circuit breaker knife switch should be closed.

2. On units equipped with interlock switch (5), Fig. 3-11, unscrew switch and pivot downward.

3. Attach the handle to the breaker (see the decal (2) on the front of the breaker for instructions on attaching handle). Depress the breaker release (1), and pull down on the handle, pivoting it against the angle on the floor. This will disconnect the primary breaker fingers from the primary studs.

NOTE: On breakers which have an interlock switch as shown in Fig. 3-11, the closing springs will be discharged when the breaker release is depressed.

   Let go of the breaker release. Pull the breaker until it stops and automatically locks in the "test" position.

4. To move the breaker from the "test" to the "disconnect" position, depress the breaker release (1), and pull the breaker out. On units equipped with interlock switch (5), Fig. 3-11, pivot downward. When the breaker moves, let go of the breaker release. Pull until the breaker stops and automatically locks in the "disconnect" position.

   Breaker knife switch can now be opened, if desired.

5. To move the breaker out of the unit from the "disconnect" position, depress the breaker release (1), and pull the breaker out. On units equipped with interlock switch (5), Fig. 3-11, pivot downward. With breakers of the type shown in Fig. 3-12, which do not

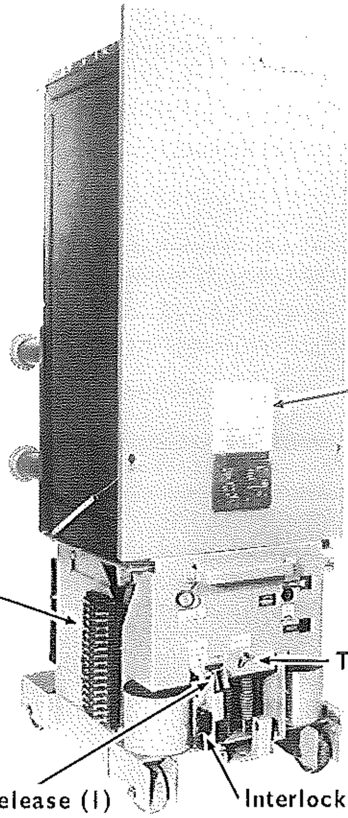


Fig. 3-11 — Circuit Breaker With Interlock Switch

Fig. 3-12 — Circuit Breaker Without Interlock Switch

have an interlock switch, the breaker closing springs will automatically discharge as the breaker starts to emerge from the cubicle.

INSERTING BREAKER, Figs. 3-11 and 3-12

1. Open the breaker by pushing the manual trip rod (3). (Interlocks will automatically trip the breaker as it enters the unit, however, manual tripping is recommended.)

2. On units equipped with interlock switch (5), Fig. 3-11, unscrew switch and pivot downward.

3. Line-up the breaker in front of the unit.

4. Open breaker knife switch.

5. Roll the breaker into the unit, push until it stops and automatically locks in the "disconnect" position. (If the closing springs were charged before insertion, they will automatically discharge before the breaker reaches the "disconnect" position.)

6. To move the breaker to the "test" position, depress the breaker release on the front of the breaker (1), and push. When the breaker moves, let go of the breaker release. Push until the breaker stops and automatically locks in the "test" position. If the circuit breaker control knife switch is closed, the springs will charge when the "test" position is reached. On units equipped

with interlock switch (5), Fig. 3-11, this action will take place when the switch is pivoted into place.

7. To move the breaker to the "connected" position, again depress the breaker release (1), and push the breaker. On units equipped with interlock switch (5), Fig. 3-11, pivot switch downward. When the breaker moves, let go of the breaker release. Continue to push toward the connected position. The breaker will come to a stop when the primary breaker fingers strike the primary studs. A handle must now be used to move the breaker to the fully connected position (see the decal (2), on the front of the breaker for instructions on attaching handle). A short upward stroke of the handle locks the breaker in the "connected" position.

8. On units equipped with interlock switch, pivot into place.

9. Close the breaker knife switch and closing springs should charge.

It is also important to guard against accidental electrical closing of the breaker. The breaker closing electric circuit is not completely contained in the switchgear cubicle, but two wires run through interconnecting wiring to the electrical cabinet of the MP45 generating unit. If the breaker knife switch is closed providing power to the breaker, and if the breaker is in the "charged" state, all that is needed to close the breaker is to connect the two wires together as is normally done in operation by a relay in the Woodward EG peaking load control box.

When doing work in the electrical cabinet, and in particular at the EG peaking load control box, it is important that precautions be taken to prevent a false electrical closure of the breaker. If the MS switch is in AUTO, touching wires at terminals 38 and 39, of the EG peaking load control box, will close the breaker. Care should be taken to ensure that tools or the box cover do not touch the terminals. If the wires are to be removed for replacement of the box, the MS switch should be OFF to open AR interlock K1-K2.

Further protection can be obtained by opening the breaker knife switch.

Referring to the wiring diagram for an MP45 in the area of coordinates D-2 will show the breaker closing circuitry. Note that the interconnecting wiring terminates at terminal board 55G points 1 and 2. Opening the breaker knife switch will prevent undesired breaker closure work is being done in this area.

SECTION 4

INSTALLATION AND PRE-SERVICE CHECK

GENERAL

The design and construction of the MU type power plant is such that the control outdoor switchgear station and MP type generating unit can be transported to and positioned at a previously prepared power plant site and put into operation without major servicing or assembly procedures. All wiring within the individual units has been connected at the factory. The connections between the power units and to the outdoor switchgear station have to be made at the site.

Since the engines have been run and tested at the factory no break-in procedure is required. After the installation has been completed and the pre-service checks have been made the units may be placed in commercial service.

Additional installation and pre-service information may be found in applicable EMD Maintenance Instructions and other publications.

WARNING: An MU installation is completely automatic and the diesel units will start by themselves when proper connections are complete. Therefore do not install the 400 ampere starting fuse until all preliminary checks have been made and the unit is ready to run.

SITE PREPARATION

The site should be prepared in advance as shown on the recommended installation drawings. Although the relative spacing and location shown on these drawings is generally the best, it can be varied to meet individual user requirements. It is important to leave enough space between the units so that easy access is provided for service equipment and supplies.

INSTALLATION

Installation of the units consists of moving them into their proper location on the previously prepared site, adding the necessary supplies, and making the proper connections to them.

Most piping and wiring between generating units and the switchgear station is made underground. It is often desirable to install the underground portion of the piping and wiring while preparing the site.

Fuel oil equalizing lines must be installed between all power units, and a supply line must be installed from the user's fuel storage tank to the power unit with fuel transfer equipment. The components to be used in a particular installation must be checked with the installation drawings.

Grounding connections should be made according to the recommended installation drawing or modified as required to meet individual customer system requirements.

The cables connecting the power units to the switchgear station are installed in a trench running between them. Generally it is not practical to move the switchgear station into place while the trench is open. Therefore, it is desirable to have all of these cables in place and the trench filled before the arrival of the units, or else wait until the switchgear station is in place before opening the trench. For the exact cable requirements refer to the field connection drawing for the particular installation.

The outdoor switchgear station to system connections are of three types, high voltage power connections, remote control connections, and the signals to the switchgear station about system conditions. The system condition signals convey such information as line voltage, position of user's load breaker, and system tie breaker position. The signals are necessary when the MU installation is equipped for such automatic operations as Transfer to Deadline Mode and Resynchronization.

The outdoor switchgear station to system connections are not considered part of the MU installation. Therefore only the terminals for these connections are shown on EMD drawings — the wiring is not shown. The power connections are made on the outside of the switchgear station and all other connections are made within the switchgear station. The remote control connections are not required for local or automatic operation of an MU and they may be installed later if desired. However, it is often more convenient to install the remote connection cables while the trench is open.

GENERATOR NEUTRAL

The generator neutral may be left ungrounded, or it can be connected with a solid or impedance type ground. Both a ground connection and a neutral connection are accessible in each power unit. It is recommended that the generator neutral connection, if any, be made by the customer to meet system requirements.

The main generator is built per NEMA standards which specify that it must be able to withstand a three phase short circuit at its terminals. It is possible, however, that under some conditions a single phase line-to-ground fault will produce fault currents exceeding those of a three phase short circuit. The customer should consider the possibility of such conditions occurring on his system and apply appropriate grounding accordingly.

SUPPLIES

Lubricating oil and cooling water must be placed in the units before operation is started. Prelubrication may be necessary if the units have been stopped for over one month. See the Engine Maintenance Manual for details.

Applicable EMD Maintenance Instructions list lubricating oil specifications, diesel fuel specifications, and proper cooling water treatment.

PRE-SERVICE CHECKS

Before the MU installation is considered complete, the following inspections and checks should be made:

1. Check all rotating equipment to see that it is mechanically free and in satisfactory operating condition. Refer to applicable deprocessing and inspection Maintenance Instruction for additional information.
2. Check engine to generator alignment as indicated in applicable Maintenance Instruction. The alignment may have become disturbed because of shocks and stresses encountered during shipment.
3. Inspect air box and oil pan as indicated in Engine Maintenance Manual.
4. Remove all protective shipping materials, silica gel bags, and plywood coverings. Particular attention should be given to removing any blocking applied to protect electrical devices such as relays, contactors and switches.

5. Check storage battery electrolyte level, specific gravity, and voltage. See that the battery cables are tightly connected. When power is available the battery charger may be connected and checked.

6. Remove and inspect circuit breakers. Make sure that the phase barrier stacks are properly installed. Manually close breaker to check for freeness. Return breaker to test position. Do not place breaker in connect position until ready to check phase rotation.

NOTE: Circuit breakers are shipped while blocked in the closed position. Blocks should be removed and the breakers moved to test or disconnect position before any power connections are made.

7. Check all wiring connections for tightness. See that all connectors and plugs are properly installed.

8. Floats for the fuel oil day tank fuel level switches are shipped loose. Remove switches from the tank and install floats on switches, then reinstall the switches.

9. Fill fuel oil day tanks with fuel oil. To do this it is necessary to make a temporary jumper connection at the ESF to permit operation of the fuel oil transfer pumps without an engine running. Be sure to remove the jumper when finished. Observe operation of float switches while filling tank.

10. Make sure that all air passages are open. Check air passages in fan compartment, radiators, and air intake filters.

11. Check operation of the lube oil circulating pump. Prior to initial operation, allow the pump to run for 15 minutes to thoroughly flush the turbocharger bearings.

CAUTION: The circulating pump switch controls operation of the immersion heater contactor. Do not energize the immersion heater until there is water in the engine cooling system. The plug may be removed from immersion heater temperature control switch (TC) until water is added to the engine cooling system. Be sure to install plug when the filling operation has been completed.

12. Check tension of vee belt drive on radiator cooling fan. Check belt tension by applying a perpendicular force of 10 to 15 lbs to each belt at midpoint of belt span, refer to Fig. 4-1. The vee belt should deflect 7/16" when the force is applied, otherwise adjustment is required. It is recommended that Vee Belt Tension Indicator 8396624 be used for making the check.

    Adjust tension of vee belt as follows:

    a. Loosen nuts on two bolts holding pillow block assembly to pillow block pedestal assembly.

    b. Loosen nut on pillow block adjusting screw.

    c. Adjust pillow block adjusting bolt for required vee belt tension. To increase tension, adjust bolt clockwise. To decrease tension, adjust bolt counterclockwise.

NOTE: When tension decreases to minimum value, readjust to maximum value. It may be necessary to elongate the slots in the pillow block pedestal assembly in order to adjust vee belt tension to the maximum value. If it is necessary to elongate the slots, the upper slot should be elongated downward 3/4" and the lower slot should be elongated downward 3/8".

d. After vee belt tension is adjusted, tighten the nuts that were loosened in Steps a and b.

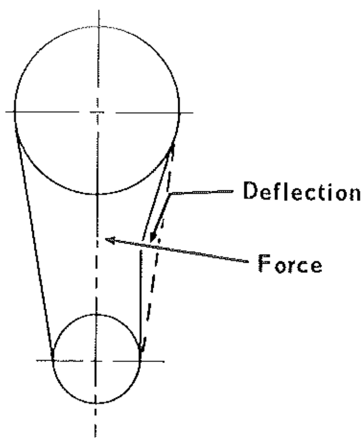


Fig. 4-1 — Checking "V" Belt Tension

PRECAUTIONS BEFORE STARTING ENGINE FOR THE FIRST TIME

It is recommended that the following checks be made immediately before starting the engine for the first time.

1. Unit manual selector switch should be in the OFF position.
2. Circuit breaker should be in test or disconnect position.
3. Make sure that all necessary fuses are in their proper position. Static exciter fuses should be removed to prevent generator excitation at this time. The electrical tests of the generator will be made when the unit is ready for the phase rotation check.
4. Battery charger should be in operation.
5. Proper positioning of all switches.
6. Check all valves for proper position.
7. Lube oil level.
8. Coolant level.
9. Governor oil level.
10. Tightness of all handhole and oil filter covers.
11. Overspeed trip lever in set position.
12. Lubricate turbocharger, by operating lube oil circulating pump, before starting engine.

After these checks are completed start engine manually from engine control panel, then make the following checks:

1. Exhaust damper valve should be open.
2. Lube oil pressure should be over 30 psi.
3. Fuel oil pressure should be over 10 psi.
4. Inspect top deck for proper lubrication.
5. All piping should be inspected for leaks.

PHASE ROTATION CHECK

A phase rotation check must be made before the units are connected to the system or to each other. All units and the line must be checked individually. Phase rotation of all units and the line must be A-B-C positive. Perform phase rotation check of line in accordance with steps 1 through 7, then perform phase rotation check of units in accordance with steps 8 through 14.

1. Be sure that system is disconnected from MU bus.

2. Make certain that all engines are shut down.
3. Set all unit circuit breakers to disconnect position.
4. Connect phase rotation meter to fuses of low voltage bus potential transformers, located in the auxiliary switchgear cubicle.
5. Connect system to MU bus.
6. Determine phase rotation of line by observing the phase rotation meter, then observe direction of rotation of the lube oil circulating pump.
7. Disconnect system from MU bus.
8. Select a unit for phase rotation check and start the engine of that unit.
9. Bring selected unit up to normal operating voltage and frequency.
10. Set unit circuit breaker of selected unit to connect position.
11. Determine phase rotation of selected unit by observing the phase rotation meter, then observe direction of rotation of the lube oil circulating pump.
12. Compare the results of step 11 with the results of step 6. If the results are not the same, the selected unit is not properly connected. Refer to installation wiring diagram for proper connections. Repeat phase rotation check of selected unit after proper connections have been made.
13. Set circuit breaker of selected unit to disconnect position.
14. Perform steps 8 through 13 for each generating unit in the MU installation.

OTHER TESTS AND CHECKS

After the phase rotation check has been completed the MU installation should be checked for proper operation in all modes.

The annunciator alarm system and engine settings should be checked.

If desired the remote controls may also be checked at this time.

SECTION 5

AUTOMATIC OPERATING SEQUENCE

GENERAL

The exact operating sequence for any given installation can only be determined from the wiring diagrams and drawings for that particular installation. However, certain characteristics of the MU type generating plant are basic and can, with only minor interpretation, be applied to most installations. An understanding of the basic operating sequence will be of value in determining the sequence for a particular plant.

Descriptions of specific components are given in Section 7 of this manual. These are arranged alphabetically so that reference to the component description can be made during the course of sequence tracing. It is recommended that a quick familiarization with the operating sequence presented herein be made before a thorough study with back reference is made.

SETTING CONTROLS FOR AUTOMATIC OPERATION

Prior to placing the generating units into automatic mode of operation, the following items should be checked.

1. All fuses in the elctrical control cabinet should be good and properly installed.
2. All high voltage fuses in the outdoor switchgear station compartments should be good and locked in position.
3. All low voltage circuit breakers in the outdoor switchgear station should be on.
4. Immersion heater and fuel transfer switches located on the engine control panels should be on.
5. Main circuit breakers should be levered to connect position.
6. All knife switches in the circuit breaker compartments and transformer compartment should be closed.
7. Main battery switch should be closed.
8. Annunciator should be clear of all fault indications.

WARNING: If engine is cold the immersion heater fault cannot be reset. In this case the engine will start automatically as soon as the manual selector switch is placed in the AUTOMATIC position.

After all of the above items are correct, the unit may be placed in automatic operation by turning the manual selector switch to the AUTOMATIC position.

BASIC OPERATING DESCRIPTION

BASIC PEAKING OPERATION, Fig. 5-I

Normally a remote momentary start signal is given individually to as many diesel driven generating units as are required for a particular peaking situation. After a start signal has been given to a unit, the battery operated motors will crank the engine, provided no fault has locked the unit out. The engine will start and warm up at idle speed for a timed period. If engine oil pressures are satisfactory after the warmup period, the speed increases from idle speed to approximately 900 RPM for a 60 cycle unit. The acceleration period requires about 8 seconds. Excitation is applied, to the alternator field, 14 seconds after the engine starts accelerating.

Terminal 11 of the peaking load control box is connected to bus voltage when the exciter is energized. Terminals 1, 2, and 3 are energized directly by generator voltage. The motor driven speed reference in the peaking load control box is allowed to run, so that the frequency of the generator will match the bus frequency.

The voltage regulator at this time will be voltage matching. The regulator has the same voltage inputs as the governor. The

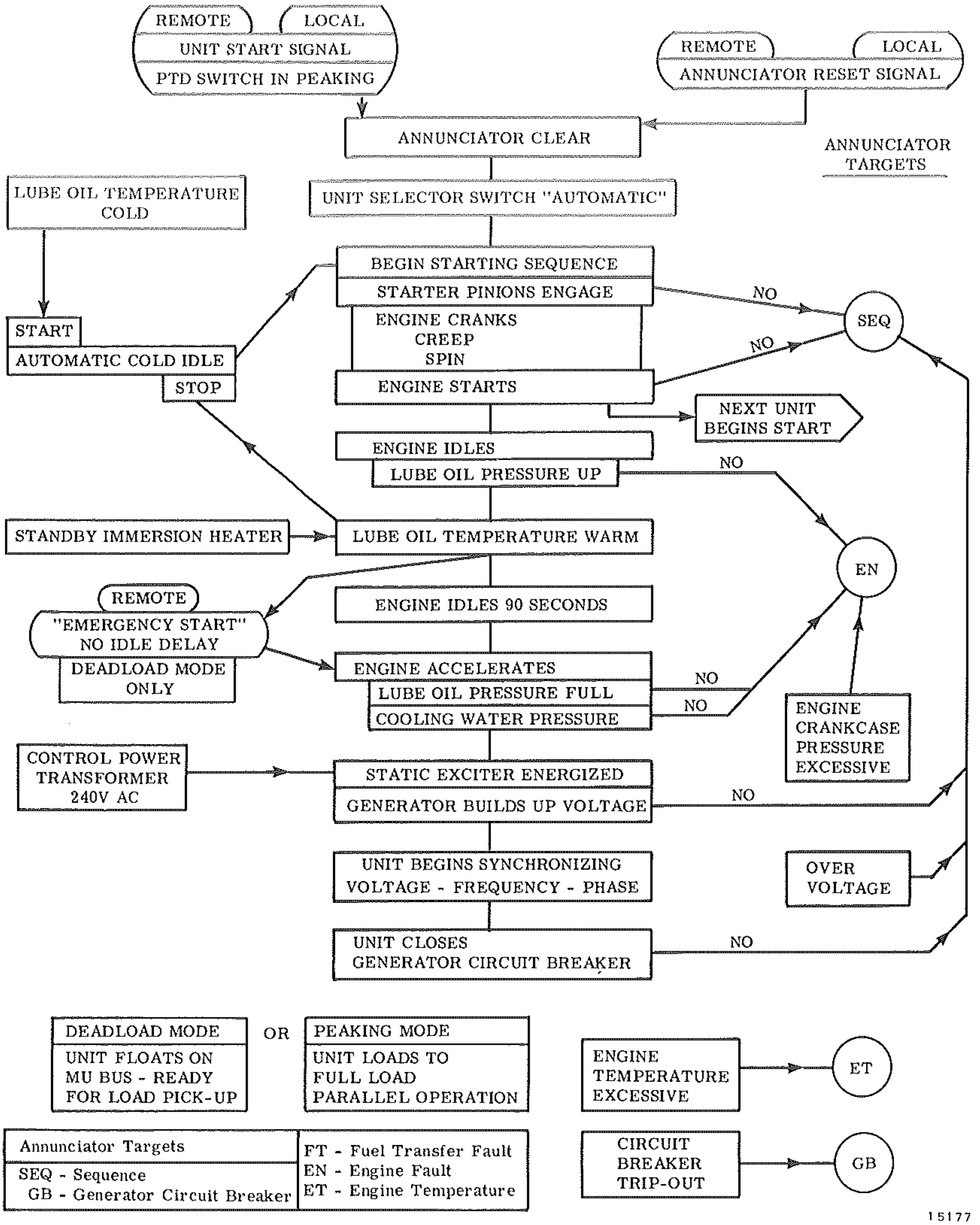


Fig. 5-1 — Automatic Starting Sequence

voltage matching circuit only operates when the generator starts to excite its field until it closes its breaker. There is no voltage matching while resynchronizing.

The automatic synchronizer section and the synchrophaser section of the peaking load control box will be comparing the frequency and phase angle of the bus voltage and the generator voltage. This circuit is entirely isolated from the frequency matching circuit described above. When the frequency of the two voltages is within a two-tenth cycle error band and the phase is matched, a relay picks up and seals in. The next time the phase is matched, another relay picks up and closes the unit circuit breaker. Phase anticipation is built into the circuit so that the breaker will close at the proper time when there is a slip between the two frequencies.

When the unit breaker has closed, there will be no difference between bus voltage and generator voltage. Therefore, the frequency matching circuit will do nothing even though it is still operative. If the bus voltage on terminal 11 of the peaking load control box were removed and another source of voltage were connected to this terminal, the motor driven speed reference would attempt to match the frequency of the MU to the frequency of the new source of voltage.

PICKING UP AN ISOLATED DEADLOAD, Figs. 5-2, 5-3, And 5-4

The basic MU power plant installation can be employed to pick up an isolated deadload through manual operation of controls. This requires the presence of an operator at the control center.

Many MU installations are provided with the capability of automatic deadload pickup. Since deadload pickup is usually an emergency situation, a start signal is given simultaneously to all generating units in the installation. However, since only one cranking battery is provided for all units, a stepping switch selects one unit at a time for cranking. After the first unit has started or has cranked for a timed period, the switch steps to apply cranking power to the next unit. The starting selector stepping switch operates until all units have been started.

After a 90 second warmup period at idle speed, the engine goes to full speed as soon as engine oil pressure is satisfactory. The first unit in an installation to reach full speed becomes the controlling unit. Its generator field is flashed by battery power, and the unit breaker closes to energize the dead MU bus. As other units come to speed, they are energized from the MU bus and then synchronize to the MU bus and close their breakers. When all units have synchronized, the user's outside load breaker is operated and the MU installation picks up the isolated deadload. For maximum deadload pickup capability, optionally installed current transformers provide field forcing current.

An Emergency Start mode of operation is available at customer's option only in conjunction with the Dead Load Pickup modification feature. The sequence of events during Emergency Start mode is the same as during Dead Load Start mode, except the 90 second warmup period at idle is bypassed during Emergency Start mode. The engine accelerates to 900 RPM as soon as oil pressure builds up to close the main bearing oil pressure switch.

CAUTION: The continued usage of this emergency start feature is detrimental to the engine, therefore, it should only be used in cases of extreme emergency and after due consideration by the user. The user should bear in mind that the low water switch, as well as the time delay to allow for cooling system venting, must be nullified in order to accomplish this total emergency mode of operation.

A special remotely mounted pushbutton switch is to be provided and installed by the customer and must be operated manually to obtain the emergency dead load start. A warning plate showing "For Emergency Start Only" is provided to identify this pushbutton switch.

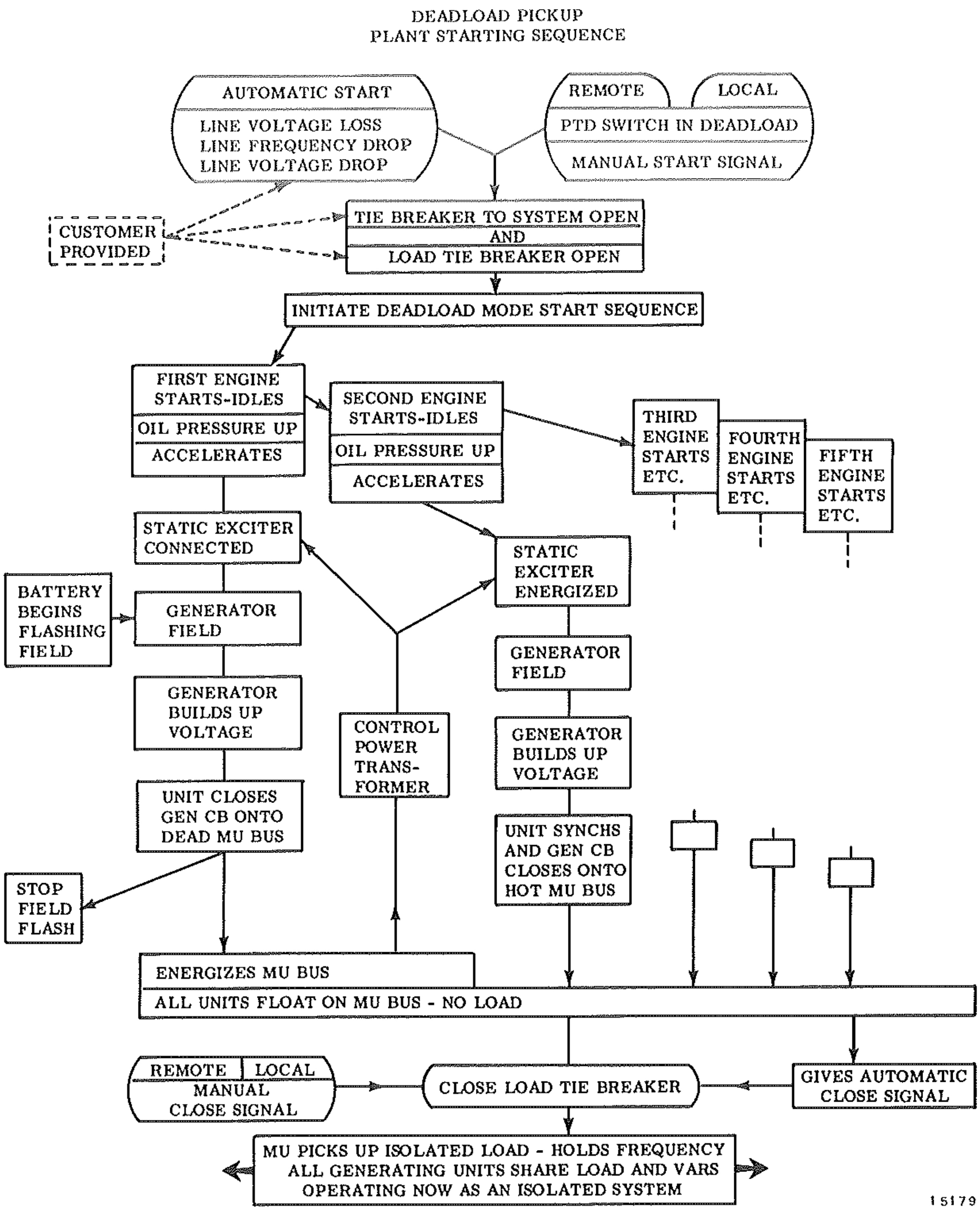


Fig. 5-2 — Deadload Pickup Plant Starting Sequence

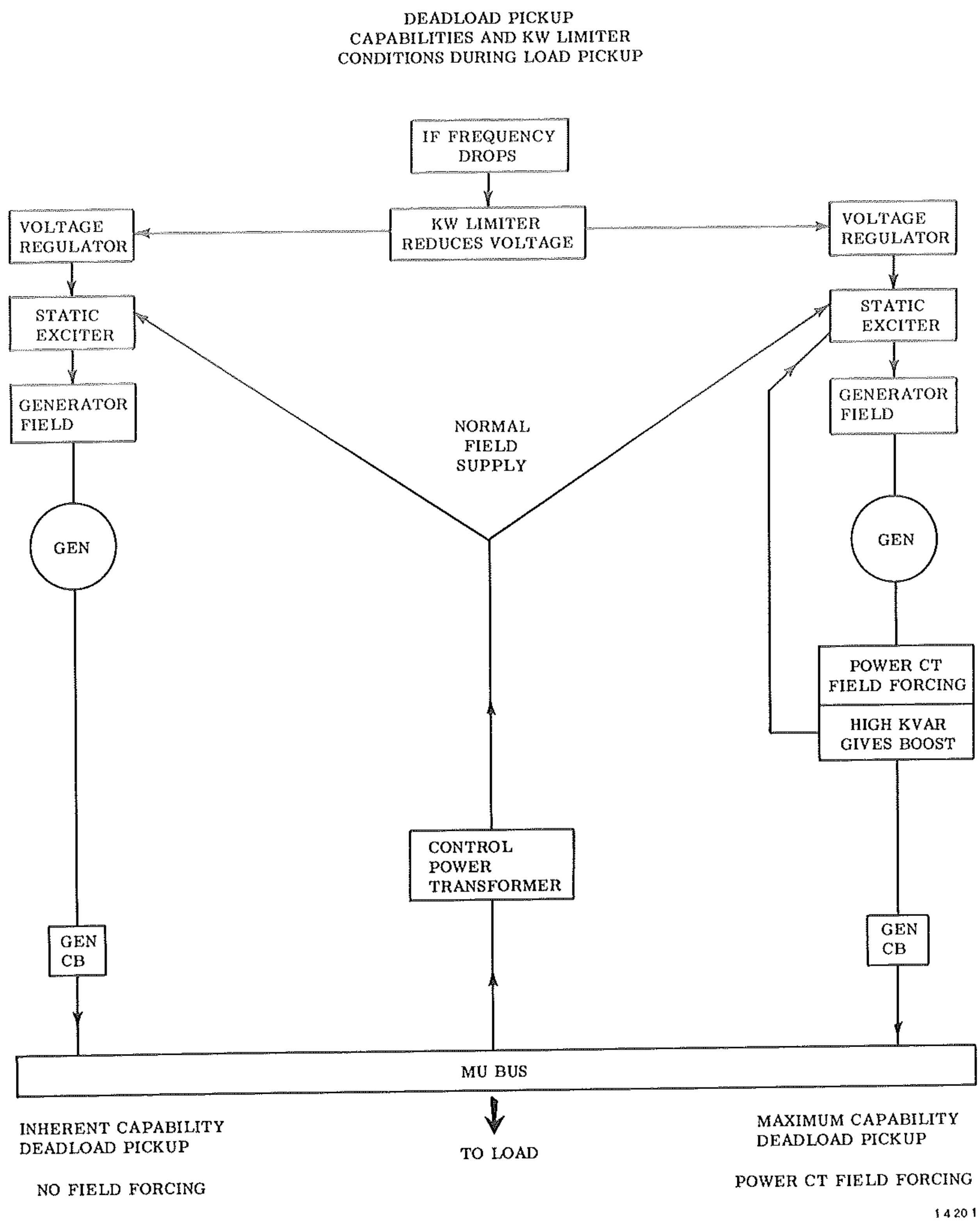


Fig. 5-3 — Deadload Pickup Capabilities And KW Limiter Conditions During Load Pickup

The basic procedures for pickup of a deadload depends upon the operational mode capability of the specific MU plant. The procedures for Basic Peaking, Basic Peaking and Manual Start Deadline Operation, and Basic Peaking and Automatic Start Deadline Operation are given in Fig. 5-4.

PROCEDURE	MU PLANT OPERATION MODE CAPABILITY		
	BASIC PEAKING ONLY (Not equipped with PTD selector)	BASIC PEAKING AND MANUAL START DEADLINE OPERATION (Equipped with PTD selector)	BASIC PEAKING AND AUTOMATIC START DEADLINE OPERATION (PTD selector not required)
Set PTD Selector	-----	DEADLINE	-----
Set MS Selector	IDLE	AUTO	AUTO
Disconnect MU From Load (52L opens)	MANUAL	MANUAL	AUTO
Disconnect MU From System (52S opens)	MANUAL	MANUAL	AUTO
Engine Start Signal	MANUAL	MANUAL	AUTO
After Engine Starts, Set MS	RUN	-----	-----
Engine Accelerates	MANUAL	AUTO	AUTO
Set MS	*EXCITE	-----	-----
Flash Generator Field	Give Manual Start Signal	AUTO	AUTO
Close Unit Circuit Breaker	MANUAL	AUTO	AUTO
Frequency Characteristics	Rides Droop Curve With Load Changes	Holds 60 CPS	Holds 60 CPS
Maintain Frequency at 60 CPS	MANUAL (Adjust as load changes)	AUTO	AUTO
Close 52L to Pick Up Deadload	MANUAL	MANUAL	AUTO
Adjust Voltages Required	MANUAL	MANUAL	MANUAL
Adjust For Load Sharing	MANUAL	AUTO	AUTO

*Leave MS set to EXCITE. If MS is set to AUTO, frequency increases and cannot be controlled by operator.

Fig. 5-4 — General Procedures For Picking Up A Deadload

"RESYNCHRONIZATION"– RESTORATION OF SYSTEM TIE, Fig. 5–5

Equipment for automatic restoration of a system tie after the MU installation has been carrying an isolated deadload is provided on all automatic start deadline units. In such equipment the MU plant uses its synchronizing capability to resynchronize with the system. When synchronization is complete, a signal is sent, and the isolated load is connected to the system. The MU installation will then revert to a peaking mode of operation in automatic resynchronization or remain where set in manual resynchronization. Initiation of resynchronization may be by operator's signal or completely automatic.

The basic procedure for resynchronizing depends upon the operational mode of capability of the specific MU plant. The resynchronizing procedures for Basic

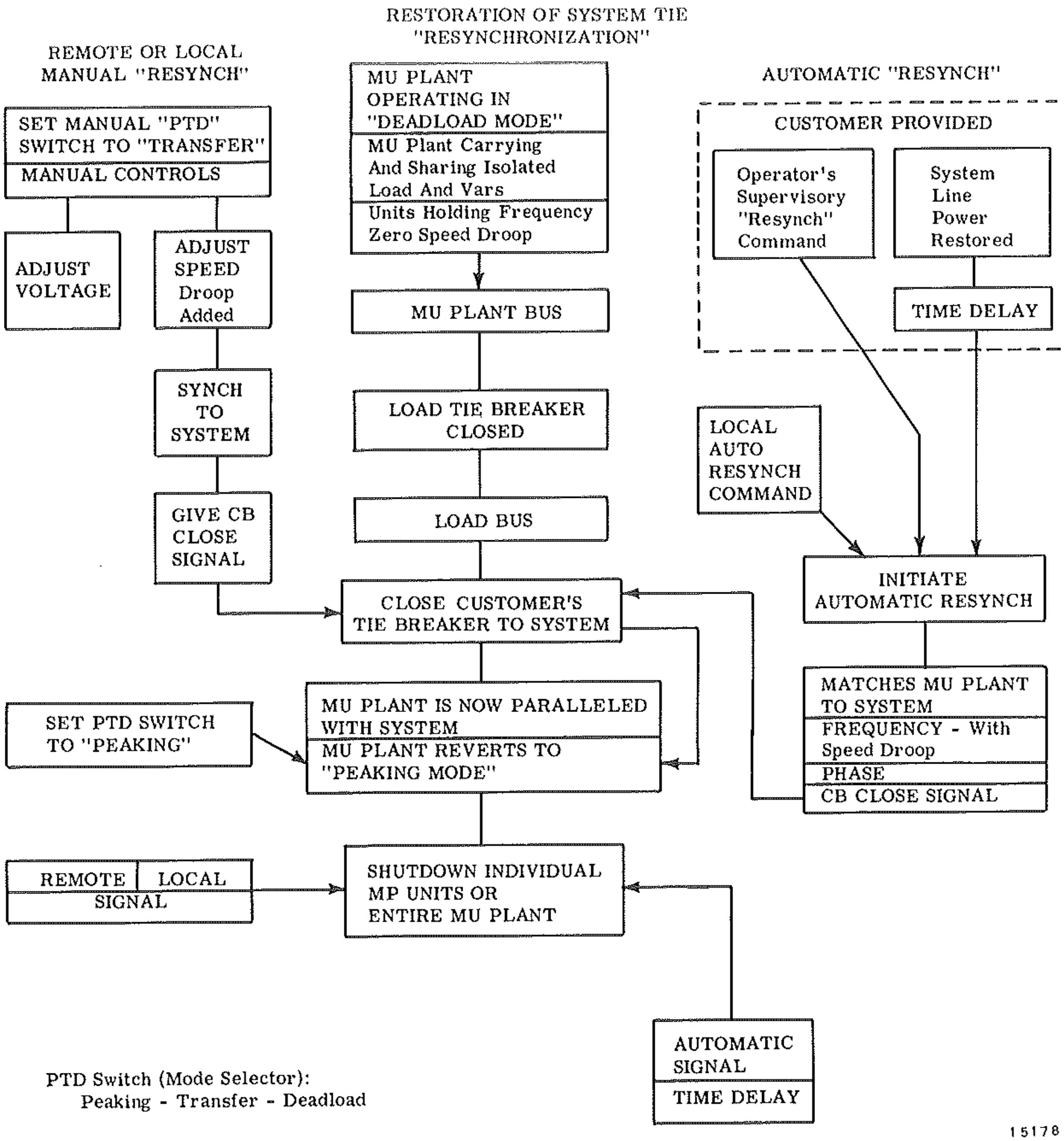


Fig. 5-5 — Restoration Of System Tie "Resynchronization"

PROCEDURE	MU PLANT OPERATIONAL MODE CAPABILITY			
	BASIC PEAKING ONLY NOT EQUIPPED FOR RESYNC.	BASIC PEAKING AND MANUAL START DEADLINE OPERATION		BASIC PEAKING AND AUTOMATIC START DEADLINE OPERATION AUTOMATIC RESYNC.
		MANUAL RESYNC.	SEMI-AUTO RESYNC.	
Initiate Resynchronization by setting PTD selector				
Set PTD selector (to initiate resynchronization)	------	TRANSFER	TRANSFER	------
Match MU Voltage to System Voltage	MANUAL	MANUAL	MANUAL	MANUAL
Match MU Frequency and Phase to System	MANUAL	MANUAL	AUTO	AUTO
Connect MU and Load to System (Close 52S)	MANUAL	MANUAL	AUTO	AUTO
Change to Peaking Mode	Already in Peaking	Set PTD to PEAKING	Set PTD to PEAKING	AUTO
Apply Full Load to MU	MANUAL (Set MS to AUTO)	AUTO	AUTO	AUTO
Initiate Shut Down of MU	MANUAL (Stop Switch)	MANUAL (Stop Switch)	MANUAL (Stop Switch)	MANUAL or AUTO
MU unloads and goes off line	AUTO	AUTO	AUTO	AUTO

Fig. 5-6 — Procedure For Resynchronizing (Tying MU Plant And Load To System)

Peaking, Basic Peaking and Manual Start Deadline Operation, and Basic Peaking and Automatic Start Deadline Operation are given in Fig. 5-6.

AUTOMATIC TRANSFER FROM PEAKING TO DEADLOAD

An MU installation equipped for automatic deadload pickup will transfer its mode of operation from peaking to deadload, upon isolation of the load from system power. The transfer is initiated by relays that respond to interlocks on customer provided system tie breakers. The controlling unit is selected by random position of the selector switch (DLS).

BASIC OPERATION SEQUENCE

The remainder of this section is provided to assist the operator in understanding the basic operating sequence of a typical MU power plant. Some fault detecting circuits and devices are mentioned in the basic operating sequence. However, to cover all fault detecting devices is beyond the scope of this chapter.

It is suggested that applicable schematic wiring diagrams be used when tracing the operating sequence presented in this chapter.

AUTOMATIC NORMAL PLANT START FOR PEAKING MODE OF OPERATION, Fig. 5-7

The sequence of events occuring during Automatic Normal Plant Start for Peaking Mode of Operation is given in Fig. 5-7. Arrows are used to indicate pickup and dropout of the relays. An arrow pointing upward indicates pickup of the relay. An arrow pointing downward indicates dropout of the relay.

Step	Procedure Or Condition	Status Or Status Assumed As Result Of Procedure Or Condition
1	PREPARATION FOR AUTOMATIC PEAKING MODE OF OPERATION	
a.	Set PTD to PEAKING	Sets up control circuits for peaking mode of operation.
b.	Set MS to AUTO	AR↑
c.	AR↑	Sets up control circuits for automatic operation.
2	STARTING SEQUENCE	
a.	Issue start signal (local or remote) to as many MP units as required for the peaking operation.	USR↑
b.	USR↑	USA↑ ; Sets up circuit to GB-O; Sets up USR holding circuit.
c.	USA↑	UST↑ ; UR↑ ; Sets up circuits to ZSR, PF, STZ, ER, and EXC.
d.	UST↑	Completes holding circuit for USR. Sets up the 11.5 minute idle timeout circuit.
e.	UR↑	STX↑ ; STRB↑ ; Sets up circuit to PF and STZ.
f.	STRB↑	Shorts out portion of RE ST to provide higher current to starter motor for engine breakaway torque.
g.	STX↑	STS↑ after 0.25 second timeout of STX.
h.	STS↑	STS interrupter contacts open; STX↓
i.	STX↓	STS↓ ; Stepping switch steps to next unit. NOTE: Steps 2g, 2h, and 2i will be repeated until closed contacts of stepping switch (STS) is connected to a "ready to start" unit (a unit whose USA and UR relays are energized).
j.	Closed contacts of STS are connected to a "ready to start" unit.	PF↑ ; STZ↑ .
k.	STZ↑	STY↑ ; GS-1↑ ; GSS↑ ; STYA↑ ; M1↑ ; and M2↑ ; STRC↑ ; Sets up SEQ-O circuit.

Fig. 5-7 — Automatic Normal Plant Start For Peaking Mode Of Operation (Sheet 1 of 4)

Step	Procedure Or Condition	Status Or Status Assumed As Result Of Procedure Or Condition
l.	STY ↑	Opens circuit to STS coil, preventing STS from stepping to next unit until a starting attempt is made on the unit selected by STS. NOTE: STY contacts A and B have a 15 second time delay in operating. If engine does not start within 15 seconds, a SEQUENCE fault will be indicated on the annunciator panel and STS will step to the next unit. The unit with a SEQUENCE fault will be "locked-out" until the annunciator is reset.
m.	GS-1 ↑ (step k)	Holds fuel injector racks at shutdown position during initial cranking period.
n.	GSS ↑ (step k)	Limits travel of fuel injector racks to approximately 1/3 rated load position during starting.
o.	STYA ↑ (step k)	Disconnects battery charger from battery during engine cranking. Battery supplies cranking power. Battery charger supplies power for control circuits.
p.	M1 ↑ and M2 ↑ (step k)	Starting pinion engages with ring gear causing ST to pick up. NOTE: If ST does not pick up within 2 seconds after step j (pickup of PF), STY will drop out causing STS to step to the next unit.
q.	ST ↑	Cranking power is applied to starting motors.
r.	STRC ↑ (step k)	STRB ↓ and STD ↑ , after 1.2 second timeout of STRC.
s.	STRB ↓	Inserts full resistance of RE ST in starting circuit for soft cranking.
t.	STD ↑ (step r)	Starts 3 second timeout of soft cranking. STR ↑ and STRA ↑ , after 3 second timeout of STD.
u.	STR ↑	Shorts out RE ST, applying full cranking power to starter motors.
v.	STRA ↑ (step t)	GS-1 ↓
w.	GS-1 ↓	Permits fuel injector racks to advance to idle speed position. Engine starts and builds up to idle speed.
x.	RE-2, in speed sensing panel, closes when engine speed reaches 140 to 210 RPM.	ESR ↑

Fig. 5-7 — Automatic Normal Plant Start For Peaking Mode Of Operation (Sheet 2 of 4)

Step	Procedure Or Condition	Status Or Status Assumed As Result Of Procedure Or Condition
y.	ESR↑	IHC↓ ; T↑ ; ESF↑ ; UR↓ ; STZ↓ ; USD↑
z.	IHC↓	Opens circuit to immersion heater.
aa.	T↑ (step y)	Activates shutter control circuit.
ab.	ESF↑ (step y)	Sets up fuel oil transfer circuit.
ac.	UR↓ (step y)	STR↓ ; STD↓ ; STX↓ ; setting up starting control circuit for next unit.
ad.	STZ↓ (step y)	STY↓ ; ST↓. Current flow through M1 and M2 reverses causing pinion to retract from ring gear, opening circuit to ST.
ae.	ST↓	M1↓ and M2↓, also starter motors are disconnected from battery.
af.	STY↓ and STD↓ (steps ac and ad)	Allows STS to step to next unit.
ag.	USD↑ (step y)	GS-11↑ and ETD↑, after 90 second timeout period of USD. NOTE: The 90 second timeout period of USD is provided to hold engine at idle during first 90 seconds of running time.
ah.	GS-II↑	Engine speed accelerates from idle speed to approximately 6% above synchronous speed. NOTE: The acceleration period requires approximately 8 seconds.
ai.	ETD↑ (step ag)	ER↑ and EXC↑, after 14 second timeout period of ETD. NOTE: The 14 second timeout period of ETD permits engine speed to increase to 6% above synchronous speed before EXC and ER picks up. However, excitation will be applied at timeout of ETD, even if engine is not at desired speed.
aj.	ER↑	Connects voltage regulator to MU bus and to peaking load control box.
ak.	EXC↑ (step ai)	ERX↑ ; ERS↑ ; ERY↑, also static exciter is connected to control power transformer. Generator field is excited from static exciter and voltage builds up, energizing GV. NOTE: A SEQUENCE normal lockout will occur if GV does not pick up prior to the 10 second timeout of ERX.

Fig. 5-7 — Automatic Normal Plant Start For Peaking Mode Of Operation (Sheet 3 of 4)

Step	Procedure Or Condition	Status Or Status Assumed As Result Of Procedure Or Condition
al.	ERS ↑	Sets up circuit to low water pressure switch (LWS) and to SEQ-O coil.
am.	ERY ↑ (step ak)	Completes circuit to low water pressure switch (LWS) and to main bearing oil pressure switch (MB2). NOTE: An ENGINE fault will be indicated on annunciator panel and unit will be locked-out, if LWS and MB2 do not pick up within the 45 second timeout period of ERY.
3	SYNCHRONIZING AND LOADING	
a.	Output of the MP unit and the MU bus voltage is applied to the peaking load control box and the EG-A control box.	Refer to description of the engine speed governor for description of synchronizing the MP unit to the MU bus.
b.	MP unit is synchronized to MU bus.	MP unit circuit breaker closes, connecting MP unit to MU bus. NOTE: A SEQUENCE fault indication is given, if the circuit breaker does not close within 90 seconds after ERS picks up (step ak).
c.	Circuit breaker is closed, connecting MP unit to MU bus.	52 VX picks up, activating the loading circuit. NOTE: Refer to description of the adjustable load reference section of the peaking load control box for description of the loading circuit.
d.	MP unit is in loading process.	At approximately 25% load, LLR is energized by closure of GOV-RS. LLR serves to trip the unit circuit breaker on unloading when the unit is being shut down. At customer's option, contacts of LLR may also be used to prevent automatic loading at 25% load and provides for manual control during the loading sequence.

Fig. 5-7 — Automatic Normal Plant Start For Peaking Mode Of Operation (Sheet 4 of 4)

NORMAL STOP SEQUENCE FROM PEAKING MODE, Fig. 5-8

The sequence of events occurring during a Normal Stop Sequence From Peaking Mode is given in Fig. 5-8. Arrows are used to indicate pickup and dropout of relays. An arrow pointing upward indicates pickup of relay. An arrow pointing downward indicates dropout of the relay.

Step	Procedure Or Condition	Status Or Status Assumed As Result Of Procedure Or Condition
1	Stop Signal Given (Local or Remote)	USR ↓
2	USR ↓	USA ↓ ; Starts 15 minute timeout of OTT ↑
3	USA ↓	UST ↓ ; USD ↓ ; Opens circuit from terminal 32 on peaking load control box.
4	UST ↓	Starts 11.5 minute idle timeout period of UST ↓
5	Terminal 32 Open	Reduces load reference signal to zero, resulting in unloading of the unit. Refer to description of adjustable load reference section of the peaking load control box.
6	Unit Unloads to Approximately 25%	GOV-RS opens.
7	GOV-RS opens	LLR ↓
8	LLR ↓	BREAKER TRIP RELAY ↑
9	BREAKER TRIP RELAY ↑	Unit circuit breaker opens.
10	Unit CB opens	52V ↓
11	52V ↓	EXC ↓ ; GS-II ↓
12	EXC ↓	Generator voltage drops to zero; Peaking load control box and EG-A control box loses control of governor.
13	GS-II ↓	Engine speed decreases to idle.
14	UST ↓ times out (11.5 minutes after step 4)	GS-1 ↑
15	GS-I ↑	Fuel injector racks go to shutdown position. NOTE: Lube oil circulating pump continues to run. Immersion heater circuit operates to maintain engine temperature at a predetermined value. NOTE: Steps 16 and 17 are applicable only if engine fails to stop within 15 minutes after step 2.
16	OTT ↑ times out (15 minutes after step 2)	OTS ↑
17	OTS ↑	Overspeed trip mechanism operates to cause immediate engine shutdown.

Fig. 5-8 — Normal Stop Sequence From Peaking Mode

AUTOMATIC DEADLINE START, Fig. 5-9

The sequence of events occurring during an Automatic Deadline Start is given in Fig. 5-9. Arrows are used to indicate pickup and dropout of the relays. An arrow pointing upward indicates pickup of the relay. An arrow pointing downward indicates dropout of the relay.

Step	Procedure Or Condition	Status Or Status Assumed As Result Of Procedure Or Condition
1	INITIATE DEADLINE START	
a.	Set MS to AUTO	AR↑
b.	AR↑	Sets up Automatic Control Circuits
c.	Set PTD to DEADLINE	52WS↑
	NOTE: Step c is not required if MU plant is equipped for fully automatic operation.	For fully automatic MU plants: 52WS picks up through auxiliary contacts (52b) of system circuit breaker. 52WL picks up through auxiliary contacts (52b) of load circuit breaker. When breakers are open, auxiliary contacts are closed.
d.	Set Plant STOP/START switch to START	PSR↑
	NOTE: Step d is not required if MU plant is equipped for fully automatic operation.	For fully automatic MU plants: PSR picks up through contacts of relay 60. Contacts of relay 60 are closed when system voltage fails.
e.	PSR↑ (Step ld)	USR↑
f.	USR↑	Starting sequence proceeds as specified in steps 2b through 2ai of Fig. 5-7.
2	OPERATION OF CONTROL CIRCUITS DURING DEADLINE STARTING SEQUENCE	
a.	52WS↑ (step 1c)	Sets up circuit for DLBC, LS DLT, and DLU. NOTE: If MU plant is equipped for fully automatic operation, 52WL has also picked up step 1c), DLBC will pick up. DLBC has a 3 second time delay in closing.
b.	USA↑ (step 1f)	DLB↑ ; DLT↑ ; DLU↑ ; LS↑ .
c.	DLB↑	DLBC↓ before 3 second timeout.
d.	LS↑	Limits travel of fuel injector racks to approximately 1/3 rated load position during engine starting.
e.	DLU↑	Sets up circuit to DLX coil, DLS coil, MR coil, and DLZ coil.
f.	DLT↑	Sets up control circuits to peaking load control box and voltage regulator. DLT also permits unit circuit breaker to remain closed when unit is operating at less than 25% rated load.

Fig. 5-9 — Automatic Deadline Start (Sheet 1 of 3)

Step	Procedure Or Condition	Status Or Status Assumed As Result Of Procedure Or Condition
g.	ETD ↑ (step 1f)	After 14 second time delay, ER ↑ , EXC ↑; DLX ↑ .
h.	ER ↑	Connects voltage regulator to MU bus.
i.	EXC ↑	ERY ↑ ; ERX ↑ ; ERS ↑ . Exciter is connected to control transformer in auxiliary switchgear cubicle. NOTE: MU bus and control transformer are dead until circuit breaker of first MP unit is closed.
j.	DLX ↑	DLS ↑ after 0.25 second time delay.
k.	DLS ↑	Deadline stepping switch steps from unit to unit until a ready to excite unit (a unit whose ERX and DLU relays are energized) is selected.
l.	ERY ↑	Sets up circuit to EN-O coil after 45 seconds time delay.
m.	ERS ↑	Sets up circuit to SEQ-O coil after 90 seconds time delay.
n.	ERX ↑	Sets up circuit to SEQ-O coil after 10 seconds time delay. Sets up circuit to MR and DLZ. MR↑ and DLZ ↑ when unit is selected by DLS.
o.	DLZ ↑	DLS ↓ . Prevents DLS from stepping to next unit.
p.	MR ↑	FFC ↑ . Sets up circuit from peaking load control box to unit breaker close, tie breaker close, and other MP units.
q.	FFC ↑	Flashes generator field by connecting battery to generator field.
r.	Generator Voltage Builds Up	FFCO ↑ ; GV ↑ .
s.	GV ↑	Unit circuit breaker closes connecting the generator to the MU bus.
t.	FFCO ↑	FFC ↓
u.	FFC ↓	Battery is disconnected from the generator field. Generator excitation is provided from the exciter. NOTE: All other MP units are excited from the MU bus. After voltage builds up the units will synchronize to the MU bus voltage, as established by the first unit. The unit circuit breakers close, on the MU bus, after synchronizing.

Fig. 5-9 — Automatic Deadline Start (Sheet 2 of 3)

Step	Procedure Or Condition	Status Or Status Assumed As Result Of Procedure Or Condition
v.	All Unit Circuit Breakers are closed on the MU Bus	DLB ↓
w.	Manually Initiate Closing of the Load Circuit Breaker NOTE: Step w is not necessary if MU plant is equipped for automatically closing the load circuit breaker. Automatic operation for closing the load circuit breaker is given in steps x through aa.	Load Circuit Breaker Closes.
x.	DLB ↓	DLBC ↑
y.	DLBC ↑	Load Circuit Breaker Closes.
z.	Load Circuit Breaker is Closed	52WL ↓ . Deadload is now connected to the MU plant.
aa.	52WL ↓	DLBC
3.	DEADLOAD IS CONNECTED TO THE MU BUS	MU plant picks up deadload and holds frequency.

Fig. 5-9 — Automatic Deadline Start (Sheet 3 of 3)

SECTION 6

MANUAL OPERATION

The MU type power plant has been designed for fully automatic operation. However, in some special situations, such as testing and maintenance operations, it is desirable to operate an MU unit under manual control. The manual controls also provide backup protection so that a unit may be operated even though the automatic circuitry is inoperative.

AUTOMATIC/MANUAL SELECTION

Selection of automatic operation or manual operation is accomplished by setting the manual selector (MS) to the desired position. MS is a six position rotary selector, located on the door of the generator switchgear cubicle within the outdoor switchgear station. The MS selector has two automatic positions, three manual positions, and an OFF position. The two automatic positions are marked "AUTO." The three manual positions are marked "IDLE," "RUN," and "EXCITE." An MP unit may be changed from automatic to manual operation or from manual to automatic operation at any time, provided the selector is not turned through the OFF position. If the selector is turned through the OFF position, the unit must be restarted before operation can be resumed.

MANUAL CONTROLS

START PUSHBUTTON

A START pushbutton is located on the engine control panel of each MP unit. To start the engine manually, set MS to idle then press and hold the START pushbutton until the engine starts. After starting, the engine will run at idle speed until MS is set to RUN or to AUTO.

STOP PUSHBUTTON

A STOP pushbutton is also located on the engine control panel of each MP unit. When the STOP pushbutton is pressed, the engine will unload and stop immediately. The 11.5 minute idle timeout is bypassed when the STOP pushbutton is used to stop the engine.

SPEED CONTROL

A governor control switch is located on each generator switchgear cubicle, in the outdoor switchgear station. The governor control switch operates the motor driven speed reference, located in the peaking load control box. The motor driven speed reference controls the speed setting of the governor.

CIRCUIT BREAKER

A breaker control switch is located on each generator switchgear cubicle in the outdoor switchgear station. The breaker control switch may be used to trip the circuit breaker at any time. The circuit breaker may also be tripped mechanically by pressing the PUSH TO TRIP trip rod located on the circuit breaker inside the generator switchgear cubicle. The breaker control switch may be used to close the circuit breaker only if the voltmeter switch, located on the generator switchgear cubicle, is turned on.

START/STOP SWITCH

A START/STOP switch is located on each generator switchgear cubicle in the outdoor switchgear station. The START/STOP switch may be used for both manual and automatic operation, depending upon the position of MS. If MS is set to AUTO, the START/STOP switch may be used for automatic operation. If MS is set to IDLE, the START/STOP switch may be used for manual operation. When the START/STOP switch is set to STOP, the unit will stop immediately. The 11.5 minute idle timeout period is bypassed.

Typically, these manual controls are used only for the desired portion of a loading sequence. As an example the following sequence might occur when it is desired to synchronize manually.

1. Unit is given automatic start.
2. When voltage builds up operator turns MS to EXCITE position. Unit will now remain at approximately full speed with generator excited until further signals are given to it.
3. Operator adjusts speed and voltage to match that of system.
4. Operator closes circuit breaker at moment of synchronism.
5. Operator returns MS to AUTOMATIC position. Unit will now complete automatic loading sequence.

MANUAL START, SYNCHRONIZING, AND LOADING FOR PEAKING

The sequence of events occurring during manual starting, synchronizing, and loading for peaking mode of operation is given in Fig. 6-1. Arrows are used to indicate pickup and dropout of the relays. An arrow pointing upward indicates pickup of the relay. An arrow pointing downward indicates dropout of the relay.

MANUAL CONTROL FOR DEADLOAD PICKUP

The sequence of events occurring during manual starting, synchronizing, and loading for deadline mode of operation is given in Fig. 6-2. Arrows are used to indicate pickup and dropout of the relays. An arrow pointing upward indicates pickup of the relay. An arrow pointing downward indicates dropout of the relay.

Step	Procedure Or Condition	Status Or Status Assumed As Result Of Procedure Or Condition
1	MANUAL START	
a.	Set MS to IDLE	IRE ↑
b.	Press START pushbutton on engine control panel or set START/STOP selector, on door of generator switchgear cubicle, to START.	USR ↑
c.	USR ↑	Starting sequence proceeds as specified in steps 2b through 2ag of Automatic Normal Plant Start, Fig. 5-7. Engine remains at idle speed.
2	INCREASE SPEED FROM IDLE TO SYNCHRONOUS SPEED	
a.	Set MS to RUN	GS-II ↑ after timeout of USD.
b.	GS-II ↑	Fuel injector racks move to increase engine speed to approximately synchronous speed.
3	APPLY EXCITATION TO GENERATOR FIELD	
a.	Set MS to EXCITE	ER ↑ ; EXC ↑ .
b.	ER ↑	Voltage regulator is connected to MU bus.
c.	EXC ↑	ERS ↑ ; ERY ↑ ; ERX ↑ ; Exciter is connected to control transformer located in auxiliary switchgear cubicle.
d.	ERS ↑	Sets up circuit for fast engine stop, bypassing the 11.5 minute idle timeout period, in case water pressure does not build up to normal.
e.	ERY ↑	EN-O ↑ causing fast engine stop, bypassing the 11.5 minute idle timeout period, if main bearing oil pressure and water pressure does not build up to normal within 45 seconds.
f.	ERX ↑	SEQ-O ↑ if generator voltage does not build up within 10 seconds after generator field is excited.
4	SYNCHRONIZE MP UNIT TO SYSTEM	
a.	Use voltage control switch to match voltage of MP unit with system voltage.	Voltage of MP unit is matched with system voltage.
b.	Use governor control switch (GCS) and synchronizing lights to synchronize frequency of MP unit with system frequency.	Frequency of MP unit is synchronized with system frequency.
c.	Set VOLTAGE/FREQUENCY selector located on generator switchgear cubicle to one of the three generator positions.	Sets up circuit for closing circuit breaker.
d.	Close MP unit circuit breaker at proper instant. (Determine proper instant by observing synchronizing lights.)	MP unit is connected to system.
e.	Use governor control switch (GCS) to adjust load on MP unit to rated load.	MP unit is operating at rated load.

Fig. 6-1 — Procedures For Manual Starting Synchronizing And Loading For Peaking Mode Of Operation

Step	Procedure Or Condition	Status Or Status Assumed As Result Of Procedure Or Condition
1	MANUAL START (Same as Peaking Mode of Operation. Refer to Fig. 6-1.)	
2	INCREASE SPEED FROM IDLE TO SYNCHRONOUS SPEED (Same as Peaking Mode of Operation. Refer to Fig. 6-1.)	
3.	APPLY EXCITATION TO GENERATOR FIELD	
a.	Set MS to EXCITE	ER ↓ ; EXC ↓ .
b.	ER ↓	Voltage regulator is connected to MU bus, but MU bus is not excited.
c.	EXC ↓	ESR ↓ ; ERY ↓ ; ERX ↓ ; Exciter is connected to control transformer located in auxiliary switchgear cubicle. Excitation will not build up because control transformer is not energized.
d.	ERS ↓	Sets up circuit for fast engine stop, bypassing the 11.5 minute idle timeout period, in case water pressure does not build up to normal.
e.	ERY ↓	EN-O ↓ causing fast engine stop, bypassing the 11.5 minute idle timeout period, if main bearing oil pressure and water pressure does not build up to normal within 45 seconds.
f.	ERX ↓	SEQ-O ↓ if generator voltage does not build up within 10 seconds after generator field is excited.
g.	Set and hold STOP/START switch located on generator switchgear cubicle, to START until circuit breaker is closed in step j.	FFC ↑
h.	FFC ↓	Generator field is excited from battery and generator voltage builds up.
i.	Set VOLTAGE/FREQUENCY selector, located on generator switchgear cubicle, to one of the three GENERATOR positions.	Sets up circuit for closing circuit breaker.
j.	Close MP unit circuit breaker, when generator voltage builds up to approximately 75% of rated voltage.	Generator excitation is maintained, by exciter, from the control power transformer located in the auxiliary switchgear cubicle.
4	ADJUST FREQUENCY AND VOLTAGE OF MP UNIT	
a.	Using governor control switch (GSC) adjust frequency of MP unit as required.	MP unit operating at required frequency. NOTE: The required frequency depends upon the load supplied by the MP unit and the droop characteristics of the MP unit. The following table applies to an MP unit with 5% droop.

Fig. 6-2 — Procedures For Manual Starting Synchronizing And Loading For Deadline Mode Of Operation (Sheet 1 of 2)

Step	Procedure Or Condition	Status Or Status Assumed As Result Of Procedure Or Condition
		% of Rated Load to be supplied by MP unit / Required Frequency Setting 20% — 1% above rated frequency 40% — 2% above rated frequency 60% — 3% above rated frequency 80% — 4% above rated frequency 100% — 5% above rated frequency
b.	Using voltage control switch, adjust voltage to rated output voltage.	MP unit operating at rated output voltage, with no load. MP unit is connected to MU bus.
5	MANUAL CONTROL FOR SECOND AND SUCCEEDING MP UNITS	
a.	Perform steps 1 through 4d of Fig. 6-1, for each of the second and succeeding MP units.	MP units are synchronized and connected to the MU bus.
6	AUTOMATIC CONTROL FOR SECOND AND SUCCEEDING MP UNITS	
a.	Set MS of each MP unit to AUTO	Sets up automatic starting control circuits.
b.	Issue start signal for each MP unit.	MP units start and synchronize to the MU bus voltage and frequency as established by the first MP unit. After synchronizing, the unit circuit breakers close connecting the MP units to the MU bus. NOTE: Set MS of each MP unit to EXCITE as soon as the unit circuit breaker closes.
7	APPLYING LOAD TO MU PLANT	
a.	Ensure that load is isolated from system power lines.	Prevents MU plant from feeding into system power lines.
b.	Close load circuit breaker 52L.	MU plant is connected to dead load.

Fig. 6-2 — Procedures For Manual Starting Synchronizing And Loading For Deadline Mode Of Operation (Sheet 2 of 2)

SECTION 7

DESCRIPTION OF ELECTRICAL DEVICES

This section of the operating manual contains descriptions of individual electrical devices as they are used in a typical MU installation. No attempt is made in this section to correlate electrical devices or to define sequences of operation. The purpose of this section is to provide a basis for primary understanding of the equipment and to provide the easiest means of back reference when operating sequences are being traced, as in Sections 5 and 6 of this manual.

The descriptions contained in this section of the manual are of necessity general and cannot cover all functions of a particular relay or device. However, since the general purpose of a given relay is common to most MU installations regardless of individual control options and user supplied equipment, the descriptions will be of value in familiarizing operators with the control equipment.

Information relative to pickup and dropout of thermal switches, speed switches, and time delay relays is provided in Fig. 7-1.

A legend of relays and other electrical devices is located in the appendix to this manual.

MAJOR DEVICES

KW LIMITER, Fig. 2-27

The purpose of the KW limiter is to protect the generating unit from an overload, when operating in deadline mode.

An AC frequency generator, mounted on the front end of the engine and driven by the camshaft, provides a frequency signal to the KW limiter. The frequency of the signal decreases when the engine speed decreases due to an overload. When the frequency decreases, the KW limiter supplies a signal to the voltage regulator to decrease excitation voltage to the alternator field, resulting in a decrease in output voltage from the alternator. The reduction in alternator output voltage results in maintaining rated speed and full load output at a reduced voltage.

ANNUNCIATOR RESET PUSHBUTTON, Fig. 2-22

The annunciator reset pushbutton, located on the electrical control cabinet of each generating unit, is provided for resetting all fault indicating circuits of the generating unit. The fault indication will reappear, if the fault persists after the reset pushbutton is pressed.

A remote annunciator reset pushbutton is provided, upon request from the customer. If an engine fault is not indicated, the remote annunciator reset pushbutton resets all fault indicating circuits except the engine fault circuit. The remote annunciator reset pushbutton is inoperative, if an engine fault is indicated.

SPEED SENSING PANEL, Fig. 2-25

The speed sensing panel prevents engagement of the starting motor pinion when engine is running and disconnects starting motor after engine is started. The speed sensing panel contains a solid state regulated power supply, solid state frequency sensing circuits, solid state switches, a solid state amplifier, and two output relays.

The regulated power supply operates from the 120 volt battery, located in the MPA unit, and provides 12 V DC for operation of the amplifier, solid state switches, and the output relays. The engine mounted AC frequency generator provides an input signal to the solid state amplifier where the signal is amplified and clipped. Output of the solid state amplifier is a constant voltage square wave signal whose frequency is directly proportional to engine speed. The square wave signal is applied to the solid state frequency sensing circuit. The output of the solid state frequency sensing circuit is a DC voltage whose magnitude is directly proportional to the frequency of the square wave input. This DC voltage is used to bias the solid state switches. When the engine speed is approximately 50 RPM, the magnitude of the bias voltage is sufficient to operate

RELAYS AND SWITCHES	DROPOUT VALUE	PICKUP VALUE
40 OCX		60 Seconds
52 VM		4 Seconds
DLBC		3 Seconds
DLX		0.25 Second
ERS		90 Seconds
ERX		10 Seconds
ERY		45 Seconds
ETD		14 Seconds
ETS	190° F.	200° F.
FFCO	85 Volts	90 Volts
FSR		120 Seconds
LOTS	85° F.	95° F.
LWS	20 PSI	30 PSI
MB1	20 PSI	30 PSI
MB2	45 PSI	50 PSI
OAD		90 Seconds
OLT		60 Seconds
OTT		15 Minutes
PF		2 Seconds
PSR		1 Second
RST	0.25 Seconds	
STD		3 Seconds
STRC		1.2 Seconds
STX		0.25 Seconds
STY		15 Seconds
T	2 Seconds	15 Seconds
TB	170° F.	175° F.
TC	150° F.	125° F.
TS	70° F.	60° F.
USD		90 Seconds
UST	11.5 Minutes	
ZSR	2 Seconds	
GOV RS	1.50 to 1.48 Inch (Rack Setting)	
LOAD LIMIT		0.79 Inch (Rack Setting)
SSP RE1	0 RPM	40 to 50 RPM (50 or 60 cycles)
SSP RE2	175 RPM MIN.	140 to 210 RPM (50 or 60 cycles)

Fig. 7-1 — Relay And Switch Settings For The MP45 Generating Units the solid state switch which energizes output relay RE1. When engine speed is approximately 200 RPM, the magnitude of the bias voltage is sufficient to operate the solid state switch which energizes output relay RE2. Function of RE1 and RE2 is given in Fig. 7-2.

VOLTAGE REGULATOR, MAGNETIC AMPLIFIER TYPE

A detailed description of the voltage regulator is given in the applicable EMD Maintenance Instruction.

RELAYS AND SWITCHES

27 LOW VOLTAGE RELAY, Figs. 3-3 And 3-4

The low voltage relay 27 drops out if MU bus voltage decreases to approximately 87.5% of rated voltage. Dropout of relay 27 results in pickup of lockout relay 86. When energized, relay 86 initiates a normal shutdown sequence with lockout protection. Refer to description of relay 86 for details.

40-OC, ALTERNATOR FIELD OVERCURRENT RELAY, Fig. 2-26

The purpose of 40-OC is to energize 40-OCX, initiating unit shutdown, in case excitation current to the alternator field rises to an abnormally high value. Abnormally high field current may result from voltage regulator failure or from manually increasing voltage output when operating at full load and high KVAR.

The operating coil of 40-OC is located on the generator and governor control panel and is connected in series with the alternator field.

40-OCX (TD), ALTERNATOR FIELD OVERCURRENT AUXILIARY RELAY, Fig. 2-25

The alternator field overcurrent auxiliary relay 40-OCX trips the unit main circuit breaker and energizes the GB-O relay which results in a GENERATOR BREAKER fault indication, and initiates a normal engine shutdown.

The operating coil of 40-OCX is energized by 40-OC in case excitation current to the alternator field rises to an abnormally high value. An operating time delay of 60 seconds is provided to prevent 40-OCX from operating on alternator field overcurrent of a transient nature.

52, MAIN CIRCUIT BREAKER

The main circuit breaker 52 connects the generating unit to the MU bus.

A main circuit breaker is installed in each generator switchgear cubicle of the outdoor switchgear station. The main circuit breaker is a 3 phase electrically operated

Output Relay	Pickup Speed	Dropout Speed	Relay Function
RE1	40-50 RPM	0 RPM	Indicates that engine is not yet running under own power. Prevents engagement of starter when engine is running. Ends overall timeout cycle.
RE2	140-210 RPM	175 RPM MIN.	Indicates that engine is running under its own power. Disengages starting motor after engine has started.

Fig. 7-2 — Function Of RE1 And RE2

air circuit breaker with a rating of 1200 amperes at 4160 volts. Interrupting capacity of the circuit breaker is 350 MVA or 250 MVA depending upon the particular installation.

Handling tools are provided to withdraw the circuit breaker from the generator switchgear cubicle. The same tools are used for inserting the circuit breaker. A guide track and locking mechanism are provided to place the circuit breaker in disconnect, test, or connect positions as required. The breaker must be levered into the connect position to lock it in place.

52a, UNIT CIRCUIT BREAKER AUXILIARY SWITCH

Unit circuit breaker auxiliary switches 52a are open when the unit circuit breaker is open and closed when the unit circuit breaker is closed. The closed contacts set up control circuits.

52b, UNIT CIRCUIT BREAKER AUXILIARY SWITCH

Unit circuit breaker auxiliary switches 52b are open when the unit circuit breaker is closed and closed when the unit circuit breaker is open. The closed contacts set up control circuits.

52TC, UNIT CIRCUIT BREAKER TRIP COIL

When energized, the trip coil opens the unit circuit breaker. The trip coil is energized through operation of various protective devices, manual switch operation, or in the normal shutdown procedure when load falls to approximately 25% of normal full load.

52V, AND 52VX, UNIT CIRCUIT BREAKER AUXILIARY RELAYS, Figs. 2-25 And 2-6

These auxiliary relays are energized by closure of the unit circuit breaker auxiliary switch 52a. When energized, 52V and 52VX issues a "unit breaker closed" signal to the control circuits.

52VM (TD), UNIT CIRCUIT BREAKER AUXILIARY RELAY, Fig. 2-24

This auxiliary relay is energized by closure of 52V. This relay sets up the circuit to the unit breaker trip relay 52TC. A four second time delay is provided to allow for pickup of relay 27 before 52VM contacts close.

52W, UNIT CIRCUIT BREAKER AUXILIARY RELAY, Fig. 2-26

The 52W relay is used in the voltage regulator circuit for voltage matching. The relay is picked up by unit start relay USA and remains picked up until the voltage is matched and the unit circuit breaker is closed.

52WL, LOAD BREAKER RELAY, Fig. 2-27

The load breaker relay 52WL is used only on the MPA units of MU plants equipped for automatic deadline operation.

The load breaker auxiliary switch 52b closes when the load breaker opens. Closure of 52b picks up 52WL which sets up the circuit to DLBC. DLBC is held in the de-energized position by DLB until all generating units are connected to the MU bus. When all units are connected to the MU bus, DLB drops out causing DLBC to pick up and issue a signal for the load breaker to close. When load breaker closes, 52WL drops out de-energizing DLBC.

52WS, SYSTEM BREAKER RELAY, Fig. 2-27

The system breaker relay 52WS is used on the MPA units of MU plants equipped for manual or automatic deadline operation.

The system breaker auxiliary switch 52b closes when the system breaker opens. Closure of 52b picks up 52WS which sets up control circuits for deadline operation.

55, LEADING VARS RELAY, Figs. 3-8 And 3-9

The leading vars relay 55 is a directional power relay connected to sense leading VARS. Operation of relay 55 issues a trip signal to the unit circuit breaker. Relay 55 operates when leading vars increase above a predetermined value.

As the generator field is reduced, either deliberately or otherwise, the magnetic coupling between the rotor and stator is weakened which allows the generating unit to fall out of step. It continues to carry load, but draws a high component of reactive power from the power system. This may be damaging to the generating unit and may cause disturbances in the power system. Relay 55 senses this condition and issues a signal which results in opening of the unit circuit breaker.

59, OVERVOLTAGE RELAY, Fig. 3-8

The purpose of overvoltage relay 59 is to sense an overvoltage condition and initiate unit shutdown by energizing the generator breaker fault relay GB-O. An overvoltage relay is provided in each generator switchgear cubicle.

When an overvoltage condition is sensed, the 59 relay initiates a normal shutdown sequence, with lockout protection, and a GB fault is indicated on the annunciator panel. Shutdown of the generating unit provides protection from an internal fault and isolation of the unit, through normal shutdown and lockout, protects the unit from an external fault. The fault must be corrected and the annunciator RESET pushbutton pressed before normal operation can be resumed.

67, REVERSE POWER RELAY, Fig. 3-8

The reverse power relay 67 senses a reverse power condition and initiates unit shutdown by energizing the generator breaker fault relay GB-O. A reverse power relay is provided in each generator switchgear cubicle.

When a reverse power condition is sensed, the 67 relay initiates a normal shutdown sequence, with lockout protection, and a GB fault is indicated on the annunciator panel. The fault must be corrected and the annunciator RESET pushbutton pressed before normal operation can be resumed.

86, LOCKOUT RELAY, Fig. 3-3

The lockout relay 86 initiates a normal shutdown sequence and locks out all unit circuit breakers when a fault is sensed by undervoltage relay 27 or differential current relay 87.

Lockout relay 86 is energized by dropout of undervoltage relay 27 or pickup of differential current relay 87. When lockout relay 86 is energized, a normal shutdown sequence with lockout protection is initiated. The annunciator panel will indicate a GB fault. The annunciator RESET pushbutton must be pressed and lockout relay 86 must be reset before normal operation can be resumed. The lockout relay 86 is located in the auxiliary switchgear cubicle. The reset switch for the lockout relay 86 is located on the front panel of the auxiliary switchgear cubicle.

87, DIFFERENTIAL CURRENT RELAY, Fig. 3-3

The differential current relay 87 protects the MU installation, by initiating a normal plant shutdown and lockout, when a ground or phase fault is detected.

Differential current transformers are used to sense the current output of the MU installation and the current output of each generating unit. During normal operation, current output of the MU installation is balanced by the current output of the generator units. If a ground or phase fault occurs within the MU installation, the currents become unbalanced. The differential current relay 87 is connected to the differential current transformers so that the current unbalance will energize the relay. Pickup of differential current relay 87 causes lockout relay 86 to pickup initiating plant shutdown. Refer to description of lockout relay 86.

On special order from the customer, individual unit differential current protection can be installed.

AR, AUTOMATIC RELAY, Fig. 2-25

The automatic relay AR sets up circuits for automatically starting the generating unit. The relay is energized only when the manual selector is set to AUTO.

CS, CIRCUIT BREAKER CONTROL SWITCH

The circuit breaker control switch CS provides manual control of the generating unit main circuit breaker. The switch is centrally located on front of each generating unit switchgear cubicle. A window in the switch position plate shows a flag to indicate the last operation of the switch; a red flag indicates that the switch was last operated to the CLOSE position; a green flag indicates that the switch was last operated to the TRIP position. The flags are not necessarily in agreement with actual position of the circuit breaker, because other devices can also operate the circuit breaker. The circuit breaker can be locked open by setting CS to the TRIP position then pulling out on CS to latch it in the PULL FOR LAMP CUTOUT position.

CAUTION: Under some circumstances the breaker may close momentarily before tripping and locking out.

DLB, DEADLINE BREAKER RELAY, Fig. 2-27

The deadline breaker relay DLB issues a signal to the deadline breaker close relay DLBC when the circuit breaker of each available generating unit is closed on the MU bus.

DLBC (TD), DEADLINE BREAKER CLOSE RELAY, Fig. 2-27

The deadline breaker close relay DLBC issues a signal to the outdoor switchgear station auxiliary cubicle resulting in closure of the load circuit breaker. The DLBC relay has a 3 second time delay in closing.

DLR, DEADLINE RELAY, Fig. 2-27

On installations equipped for automatic deadload pickup: When the deadline relay

DLR is de-energized, in conjunction with breaker operated switches and other equipment provided by the customer, a signal is issued that results in operation of a variety of auxiliary relays. The number of auxiliary relays and their functions are dependent upon the customers equipment and options selected.

The deadline relay DLR is connected from the bus metering power transformer to system ground and is de-energized when the MU bus is de-energized. When DLR is de-energized the deadline sequence of operation is initiated. This includes closing the circuit breaker of first generating unit to be excited onto the dead MU bus without synchronizing.

If an attempt is made to start a unit with the PTD (peaking, transfer, deadline) switch set to DEADLINE, but with a hot bus, DLR will be energized and the circuit breaker will not close without synchronizing.

DLS, DEADLINE STEPPING SWITCH RELAY, Fig. 2-27

The deadline stepping switch relay DLS initiates the sequence for flashing the generator field with battery voltage.

When a deadline start signal is given, the deadline stepping switch relay DLS steps from unit to unit searching for a unit that is ready to be excited; i.e., a unit whose ETD has timed out. When a ready to excite unit is located, DLS completes the circuit to the MR relay. The MR relay energizes the FFC relay which connects the battery to the generator field. When generator voltage builds up, the FFCO relay energizes causing the FFC relay to drop out, disconnecting the battery from the generator field.

DLT, DEADLINE RELAY, Fig. 2-28

In automatic deadline operation, the deadline relay DLT permits the unit circuit breaker to stay in the closed position when the unit is operating at less than 25% of full load.

DLU, DEADLINE UNIT RELAY, Fig. 2-28

The deadline unit relay DLU sets up enabling circuits for a deadline sequence start when the MU bus is de-energized and the system breaker is open.

DLX (TD), DEADLINE EXCITATION ENABLE RELAY, Fig. 2-27

The deadline excitation enable relay energizes DLS when the ETD relay, of any unit, has timed out. This permits DLS to start stepping from unit to unit until a "ready to excite" unit is located. DLX has a 0.25 second time delay in closing.

DLZ, DEADLINE RELAY, Fig. 2-27

The deadline relay DLZ removes power from DLS when a "ready to excite" unit is selected. The DLZ relay also connects input power from the MU bus to the KW limiter after the unit circuit breaker closes on the MU bus.

ER, EXCITATION RELAY, Fig. 2-26

When the ETD relay closes, the excitation relay ER connects the voltage regulator to the MU bus and the EXC relay connects the static exciter to the control power transformer. The voltage regulator and static exciter regulates the output voltage of the generator.

ERS (TD), EXCITATION RELAY, Fig. 2-25

The excitation relay ERS signals an ENGINE fault in case the low water pressure switch LWS fails to trip within 90 seconds after EXC relay operates. The ERS relay also signals a SEQUENCE fault if the unit circuit breaker fails to close within 90 seconds after EXC relay operates. The ERS relay has a 90 second time delay in closing.

ERX (TD), EXCITATION RELAY, Fig. 2-25

The excitation relay ERX signals a SEQUENCE fault, if generator voltage is not sufficient to energize the generator voltage relay GV within 10 seconds after excitation is applied to the generator field. The excitation relay ERX has a 10 second time delay in closing.

ERY (TD), EXCITATION RELAY, Fig. 2-25

The excitation relay ERY signals an ENGINE fault, if the main bearing oil pressure switch MB2 fails to open within 45 seconds after excitation is applied to the generator field.

ESF, ENGINE SPEED/FUEL TRANSFER RELAY, Fig. 2-24

The engine speed/fuel transfer relay ESF sets up the fuel transfer circuit to energize the fuel transfer relays FTC1 and FTC2 when the fuel transfer switches are closed. The engine speed/fuel transfer relay ESF is energized by ESR when engine speed reaches approximately 200 RPM.

ESR, ENGINE SPEED RELAY, Fig. 2-25

The engine speed relay ESR is energized by RE2 when engine speed is approximately 200 RPM.

The engine speed relay ESR initiates removal of power from the engine cranking circuit and de-energizes IHC when engine speed increases to approximately 200 RPM. The ESR relay also provides for the fuel transfer control circuit, crankcase pressure shutdown capability, low oil pressure shutdown capability, shutter control circuit, and the idle time delay circuit.

ETD (TD), EXCITER TIME DELAY RELAY, Fig. 2-25

The exciter time delay relay ETD permits engine speed to increase from idle to synchronous speed before excitation is applied to the generator field. The exciter time delay relay ETD has a time delay of 14 seconds.

ETI, ELAPSED TIME INDICATOR, Fig. 2-22

An ETI is connected, through a potential transformer, to the output of each generator. The purpose of the ETI is to indicate total operating time of the generating unit. The ETI indicates operating time in hours and tenths of an hour.

ETS, ENGINE WATER TEMPERATURE SWITCH, Fig. 2-9

The engine water temperature switch protects the engine by initiating shutdown, whenever an overtemperature condition is detected.

The sensing element of ETS is installed in the temperature control manifold and operates whenever water temperature in the manifold is approximately 15° F., below boiling point. Water in the engine is approximately 15° F., higher than the water in the temperature control manifold.

EXC, EXCITER CONTACTOR, Fig. 2-26

Exciter contactor EXC energizes the static exciter from the control power transformer, located in the auxiliary switchgear cubicle, when the engine approaches synchronous speed. Excitation of EXC is controlled by exciter time delay relay ETD.

FFC, FIELD FLASHING CONTACTOR, Fig. 2-25

The field flashing contactor FFC excites the alternator field from the battery for field forcing, when the generating unit is preparing to operate into a dead line.

FFCO, FIELD FLASHING CUTOUT RELAY, Fig. 2-25

The purpose of FFCO is to de-energize FFC, disconnecting battery from the alternator field, when field excitation can be sustained by the static exciter with power from the control power transformer.

FSR, FAST START RELAY, Fig. 2-28

The fast start relay is used only when the generating unit is operating in dead line, emergency start, mode. The purpose of FSR is to bypass the 90 second idle delay period during engine start-up. When FSR is energized, the engines increase to synchronous speed as soon as oil pressure permits.

The fast start relay is energized by a remote "emergency start" signal. Upon customers request, provisions will be made to energize FSR whenever a dead load start signal is given.

FTC1 AND FTC2, FUEL TRANSFER RELAYS, Fig. 2-19

Fuel transfer relays FTC1 and FTC2 energize the fuel transfer pump motors. The fuel transfer pumps transfer fuel oil from the fuel oil storage tanks to the fuel oil day tanks of the generating units. When any generating unit is running, the engine speed/fuel transfer relay ESF is energized and supplies power to the fuel transfer switches FTSL, FTSN, and FTSH. The fuel transfer switches, operated by fuel level in the fuel oil day tank, controls power to FTC1 and FTC2 as required to maintain proper fuel level in the fuel oil day tanks.

FTM, FUEL TRANSFER PUMP MOTOR, Fig. 2-4

The fuel transfer pump motor FTM drives the fuel transfer pumps, which transfer fuel from the fuel oil storage tank to the fuel oil day tanks of the generating units.

Two fuel transfer pumps, with motors, are installed on the MPA unit of each MU installation. During normal operation, only one fuel transfer pump operates. The second fuel transfer pump is provided for backup operation.

FTSL, FUEL TRANSFER SWITCH-LOW LEVEL, Fig. 2-4

The low level fuel transfer switch FTSL is operated by a float mounted in the fuel oil day tank of the MPA unit. When fuel in the fuel oil day tank decreases to an abnormally low level, the two sets of normally open contacts on FTSL close. One set of contacts, when closed, energizes FTC2, which operates to energize the backup fuel transfer pump motor. The second set of contacts, when closed, energize the fuel transfer annunciator relay, causing the FUEL TRANSFER annunciator light to come on, indicating a fault in the fuel transfer system. The fault indication does not affect engine performance, but the fuel transfer system should be checked to prevent engine shutdown due to a lack of fuel.

FTSN AND FTSH, FUEL TRANSFER SWITCHES – NORMAL AND HIGH LEVEL, Fig. 2-4

The normal and high level fuel transfer switches FTSN and FTSH are operated by a common float mounted in the fuel oil day tank of the MPA unit.

When fuel in the MPA unit fuel oil day tank decreases to approximately 5-1/2" below the centerline of the float mounting assembly, the normally open contacts of FTSN close. When the contacts are closed, FTC1 is energized causing the fuel transfer pump to transfer fuel from the storage tank to the fuel oil day tank.

Two sets of contacts are provided on FTSH. When fuel level in the fuel oil day tank is at the float mounting assembly centerline, both sets of contacts are open which prevents operation of the fuel oil transfer pump motors. When fuel level decreases to approximately 3-1/2" below the float mounting assembly centerline, one set of contacts close to energize the fuel transfer pump motor. If the fuel level should increase to approximately 3-1/2" above the float mounting assembly centerline, the other set of contacts close causing a FUEL TRANSFER fault indication on the annunciator.

GCS, GOVERNOR CONTROL SWITCH

The governor control switch GCS is provided for manually controlling the speed of the diesel engine within the range of approximately 56 cycles to 64 cycles. It is used during manual speed setting, manual synchronizing, and manual loading of the generating unit while in peaking mode or during transfer operation. The switch is located on the door of each generating switchgear cubicle. A remote governor control switch can be provided upon request from the customer.

GN, GOVERNOR NEUTRAL RELAY

The governor neutral relay GN has a set of normally closed contacts that permits the engine speed governor to automatically control diesel engine speed. When GN is energized, the contacts are open and engine speed must be controlled manually by GCS. The governor neutral relay is used during manual resynchronization. The relay is located in the outdoor switchgear station within the local control box.

GOV RS, GOVERNOR RACK SWITCH

The governor rack switch GOV RS operates to initiate a normal shutdown when load on the generating unit decreases to approximately 25% of full load.

The GOV RS is a normally open, mechanically operated, switch located in the engine speed governor. When a generating unit is in process of going on the line, the GOV RS remains open until the fuel racks are at approximately 25% of full load position, then GOV RS closes which energizes LLR allowing the circuit breaker to close and remain closed.

When load on the generating unit decreases, the fuel racks move toward the low load position. When the fuel racks reach a position equivalent to 25% of full load, the GOV RS opens de-energizing LLR which causes the main circuit breaker to open.

GOVERNOR TRANSDUCER

The governor transducer controls injection of fuel to the diesel engine, and therefore the speed or load of the diesel engine, by positioning the governor mechanisms that determine the position of fuel injector racks. The governor transducer exerts a force, on the governor mechanisms, that is directly proportional to the electrical signal, in milliamperes, received from the EG-A control box.

GS-1, GOVERNOR SPEED SETTING SOLENOID - IDLE

The governor idle speed setting solenoid GS-1 is energized during the first 4 seconds of engine cranking. When GS-1 is energized, the injector rack is held at the fuel cutoff position. After 4 seconds of engine cranking, GS-1 is de-energized allowing the injector rack to advance to the idle speed setting and injecting fuel into the cylinders for starting.

GS-2, GOVERNOR SPEED SETTING SOLENOID - FULL SPEED

When energized, the governor full speed setting solenoid GS-2 advances the injector racks to the full speed position. Full speed position is approximately 6% above synchronous speed. When the engine is near full speed, the electrical portion of the engine speed governor reduces engine speed to synchronous speed.

GV, GENERATOR VOLTAGE RELAY, Fig. 2-26

The GV relay permits a SEQUENCE fault to be indicated, if the relay is not energized within 10 seconds after excitation is applied to the generator field. The GV relay also initiates closing the first available generating unit circuit breaker when operating in the deadline mode. The operating coil of the GV relay is connected to the generating unit metering potential transformer.

IHC, IMMERSION HEATER CONTACTOR, Fig. 2-26

The purpose of IHC is to apply power to the immersion heater during engine shutdown to maintain engine lube oil at a predetermined temperature. The warmed lube oil ensures proper lubrication when starting a cold engine.

The IHC operating coil is in series with the immersion heater temperature control switch TC and with normally closed contacts of the engine speed relay ESR. The TC switch is closed, allowing IHC to be energized, when lube oil temperature is below a predetermined value. If the lube oil temperature rises above this value, TC opens to remove power from the immersion heater. When the engine is started and the speed increases to approximately 200 RPM, the normally closed contacts of ESR opens and de-energizes IHC.

IRE, IDLE/RUN/EXCITE RELAY, Fig. 2-26

The IRE relay sets up various circuits for manual control of the generating unit. The IRE relay is energized when the manual selector is set to IDLE, RUN, or EXCITE.

LLR, LOW LOAD RELAY, Fig. 2-26

The purpose of LLR is to cause the unit circuit breaker to open when load on the generating unit decreases to approximately 25% of full load. Operation of LLR is controlled by the governor rack switch GOV RS. Refer to description of GOV RS.

LTR, LOW OIL TEMPERATURE RELAY, Fig. 2-25

The low oil temperature relay LTR issues an engine start signal when the lube oil temperature decreases below a predetermined value.

During shutdown, the immersion heater operates to heat the lube oil to a predetermined temperature. If a fault develops in the immersion heater circuit or during extremely cold weather the lube oil temperature may decrease below the predetermined value causing the low oil temperature switch to close, energizing LTR. When LTR is energized, an engine start signal is issued. LTR also opens the circuit to GS-II, preventing the engine speed from increasing above idle. The engine will idle for 11.5 minutes after lube oil temperature reaches the predetermined value. After the 11.5 minute period, the engine will shut down unless a plant start signal was given during this period. If a plant start signal was issued, the generating unit will come up to speed and go on the line in a normal manner.

LTRA, LOW OIL TEMPERATURE AUXILIARY RELAY, Fig. 2-25

The auxiliary low oil temperature relay LTRA issues a low oil temperature fault indication, when lube oil temperature decreases below a predetermined value. The operating coil of LTRA is connected in parallel with LTR and is energized by closure of LOTS.

LOTS, LOW OIL TEMPERATURE SWITCH, Fig. 2-6

The low oil temperature switch LOTS closes when lube oil temperature decreases below a predetermined value. Closure of LOTS energizes LTR and LTRA causing an engine start signal, and a low oil temperature fault indication, to be issued.

A lack of oil or a defective lube oil circulating pump will also cause LOTS to close, resulting in an engine start signal. In the case of lack of oil, MB-1 will issue an engine shutdown signal and an ENGINE fault indication, due to low oil pressure.

LWS, LOW WATER PRESSURE SWITCH, Fig. 2-9 And Fig. 2-19

The low water pressure switch LWS provides an ENGINE fault indication and initiates engine shutdown in case of low water pressure.

The LWS is located in the engine control cabinet and is connected into the right bank water pump outlet. LWS will actuate to issue an ENGINE fault indication and initiate engine shutdown, if water pressure is not present within 45 seconds after excitation is applied to the generator field.

MBR, MAIN BEARING RELAY, Fig. 2-25

The purpose of MBR is to provide an ENGINE fault indication and initiate engine shutdown, if main bearing oil pressure has not reached a predetermined value within 90 seconds after engine speed reaches 200 RPM. The MBR also sets up the ENGINE fault circuit to issue an ENGINE fault and initiate engine shutdown if oil pressure should drop below a predetermined level at any time after the 90 second idle period or in case positive crankcase pressure occurs. When energized, MBR disables the unit engine starting circuit.

MBX, MAIN BEARING AUXILIARY RELAY, Fig. 2-25

The main bearing auxiliary relay MBX nullifies the oil alarm delay relay OAD, by setting up the ENGINE fault circuit as soon as lube oil pressure is sufficient to close MB-1. This permits the crankcase pressure detector to initiate engine shutdown as a result of low lube oil pressure or positive crankcase pressure.

MB-1, MAIN BEARING OIL PRESSURE SWITCH, Fig. 2-19

The main bearing oil pressure switch MB-1 energizes MBR when oil pressure to the main bearings builds up to a predetermined value. An ENGINE fault will be indicated and engine shutdown will be initiated, if MBR is not energized within 90 seconds after engine speed reaches 200 RPM.

The MB-1 switch is located in the engine control cabinet and is connected to the lube oil pressure monitor line, Fig. 2-6.

MB-2, MAIN BEARING OIL PRESSURE SWITCH, Fig. 2-19

The main bearing oil pressure switch MB-2 provides an ENGINE fault indication and initiates engine shutdown, if oil pressure to the main bearings does not build up to a predetermined value within 45 seconds after excitation is applied to the generator field.

The MB-2 switch is located in the engine control cabinet and is connected to the lube oil pressure monitor line, Fig. 2-6.

MR, MASTER RELAY, Fig. 2-28

The master relay MR is used only in the deadline mode of operation. Purpose of the master relay MR is to set up the unit circuit breaker, of first available generating unit, for closing on the MU bus when GV is energized.

The MR of a generating unit is energized when DLS selects that unit to be the lead unit, during deadline mode of operation. When MR of a unit is selected, DLS stops stepping and the MR of all other generating units are inactive.

MRG, MOTOR DRIVEN RHEOSTAT

The motor driven rheostat MRG with associated control circuit is used to change the generating unit from isochronous to droop operation when transfering from deadline mode to peaking mode of operation.

When operating in deadline mode, the rheostat is driven to the full resistance position. In the transfer mode the rheostat is slowly driven to minimum resistance position. This causes the engine speed governor to change from isochronous to droop operation.

MRV, MOTOR DRIVEN RHEOSTAT

The motor driven rheostat MRV is used only in peaking mode. The voltage range of the generating unit is set at the factory by adjusting RH1. The operator can control the voltage within the set range by using the voltage control switch. The voltage control switch controls the motor driven rheostat. This provides a means of manual voltage matching and also a means of controlling VARS from the generating unit.

MS, MANUAL SELECTOR, Fig. 3-8

The manual selector MS permits the operator to manually select the operation desired for the generating unit. It is a six pole rotary selector, located on the door of each generator switchgear cubicle, in the outdoor switchgear station. The MS has six positions; OFF, IDLE, RUN, EXCITE, and two AUTO positions. Each position energizes relays necessary to perform the operation selected.

NLO, NORMAL LOCKOUT RELAY, Fig. 2-25

The normal lockout relay NLO prevents an engine start or initiates shutdown of a generating unit, whenever a fault prevents NLO from becoming energized.

The NLO is energized, allowing normal operation, when protective relays GB, EN, ET, and SEQ are set. If any of the above named protective relays are tripped, NLO is de-energized. The generating unit is locked out when NLO is de-energized.

When tripped, the protective relays may be reset by pressing the RESET pushbutton on the annunciator panel, provided the fault has been corrected. The relays may be reset from a remote location, provided an ENGINE fault is not indicated.

OAD (TD), OIL ALARM DELAY RELAY, Fig. 2-25

The oil alarm delay relay OAD prevents a low oil alarm shutdown while oil pressure is building up during the engine starting sequence.

The operating coil of OAD is energized by closure of ESR when engine speed increases to 200 RPM. The contacts of OAD close after a time delay of 90 seconds. A low oil pressure shutdown will occur if MBR is not energized, by closure of MB-1, prior to closure of OAD contacts. OAD contacts have a time delay of 90 seconds in closing.

OLT (TD), OVERLOAD TIMER RELAY Fig. 2-28

During deadline mode of operation, the overload timer relay OLT permits overloading of the generating unit for 60 seconds without current limiting.

When an overload condition is sensed, SC1 and SC2 picks up to energize OLT. The contacts of OLT have an operating time delay of 60 seconds. If the overload continues for more than 60 seconds, the normally closed contacts of OLT open to activate the current limiting section of the voltage regulator.

OTL, OVERSPEED TRIP LIMIT RELAY, Fig. 2-25

The overspeed trip limit relay OTL energizes the ENGINE fault indication circuit which initiates engine shutdown, when the engine overspeed trip lever is in the tripped position.

When the engine overspeed trip lever moves to the tripped position, the overspeed trip limit switch OTLS closes energizing OTL. When OTL contacts close, EN-O is energized causing an ENGINE fault indication and initiating engine shutdown.

OTLS, OVERSPEED TRIP LIMIT SWITCH, Fig. 2-13

The overspeed trip limit switch OTLS energizes OTL, when the overspeed trip lever moves to the tripped position. OTLS is located at the upper front portion of the engine, below the overspeed trip solenoid and near the overspeed trip lever.

OTS, OVERSPEED TRIP SOLENOID, Fig. 2-13

The overspeed trip solenoid OTS trips the overspeed trip lever, following abnormal operation of the master relay, loading relay, or main circuit breaker auxiliary relay.

Tripping of the overspeed trip lever initiates an engine shutdown that is independent of the governor and normal stop circuits. The overspeed trip lever must be manually reset before a sucessful start can be made.

OTT, OVERSPEED TRIP RELAY (OVERALL TIMEOUT), Fig. 2-25

The overspeed trip relay energizes the overspeed trip solenoid OTS, initiating engine shutdown, if abnormal operation of the master relay, loading relay, or main circuit breaker auxiliary relay prevents completion of the starting or stopping cycle. The OTT contacts have an operation time delay of 15 minutes.

PF (TD), PINION FAILURE RELAY, Fig. 2-25

The pinion failure relay PF initiates a unit SEQUENCE normal lockout, if the pinion does not engage within 2 seconds after PF is energized. The PF contacts have an operation time delay of 2 seconds.

PFS, PINION FAILURE STEPPING SWITCH, Fig. 2-25

The pinion failure stepping switch PFS provides for three attempts at pinion engagement before a SEQUENCE fault indication is issued.

During a starting attempt, a pinion failure occurs if the pinion does not engage before PF times out. When a pinion failure occurs, STS steps to the next unit and PFS steps to the next position of the PFS switch. After three pinion failures on the same unit a SEQUENCE normal lockout occurs.

PSR (TD), PLANT START RELAY, Fig. 2-27

The plant start relay PSR energizes USR, initiating an automatic starting sequence, when the master selector is in AUTO position. The PSR contacts have an operation time delay of 1 second.

PTD, PEAKING, TRANSFER, DEADLINE SELECTOR

The peaking, transfer, deadline selector PTD provides manual control for transfer to different modes of operation. The PTD selector is located in the local control box of the outdoor switchgear station.

RE1 AND RE2, ENGINE SPEED RELAYS

The engine speed relays RE1 and RE2 are contained in the speed sensing panel. For description and operation of RE1 and RE2, refer to description of the speed sensing panel.

RH1, VOLTAGE RANGE ADJUST TANDEM RHEOSTAT, Fig. 2-26

The voltage range adjust tandem rheostat RH1 is set at the factory for the desired range of voltage for peaking mode of operation. The factory setting should not be changed except by qualified maintenance personnel.

RH2, VOLTAGE RANGE ADJUST RHEOSTAT

The voltage range adjust rheostat RH2 is set at the factory for the desired range of voltage for deadline mode of operation. The factory setting should not be changed except by qualified maintenance personnel.

RS, RESYNCHRONIZING RELAY, Fig. 2-27

During resynchronization, the RS relay is picked up by closure of RST contacts. When energized, RS disconnects terminal 11 (synchronizing reference input terminal) of the EG peaking load control box from the MU bus and connects it to system voltage. The relay also sets up the "tie breaker close" circuit, energizes MRG, and completes a circuit from MRG to the motor driven speed reference in the EG peaking load control box. Operation of MRG changes the governor from isochronous to droop operation.

RSR, RESYNCHRONIZING RELAY, Fig. 2-27

During resynchronizing, the RSR relay is picked up by DLL when the governor has been changed from isochronous to droop operation. When energized, RSR issues a signal indicating that the governor is operating as droop governor and the "tie breaker close" circuit is set up by RSR.

RST (TD), RESYNCHRONIZING RELAY, Fig. 2-27

The RST relay initiates resynchronizing after power is restored to the system. The relay operates automatically on MU installations equipped with a 60 relay or the relay may be operated by manually setting the PTD selector to the TRANSFER position.

RSU, RESYNCHRONIZING RELAY, Fig. 2-28

The RSU relay is picked up by closure of RST contacts. During deadline operation the speed reference from the EG peaking load control box is supplied from the RESET potentiometer, which is set at 60 cycles, and the motor driven speed reference is disconnected. During resynchronizing, RSU operates to supply power to the circuit of the motor operated speed reference and changes the reference from the RESET potentiometer to the motor driven speed reference.

SC1 AND SC2, CURRENT RELAYS, Fig. 2-28

Current relays SC1 and SC2 sense load current of the generating unit and energize OLT in case an overload occurs.

If an overload persists for more than 60 seconds, OLT contacts close, activating the current limiting section of the voltage regulating unit. Current limiting will continue as long as the overload is sensed. When the overload is removed, SC2 will drop out, de-energizing OLT, permitting normal operation without current limiting.

SS, START-STOP SWITCH, Fig. 3-8

The START-STOP switch SS is used to start or stop the generating unit from the outdoor switchgear station. A START-STOP switch is located on each generator switchgear cubicle. A remote START-STOP switch can be provided upon request from customer.

ST, STARTING CONTACTOR, Fig. 2-25

The starting contactor ST connects the engine starting motors to the battery located in the MPA unit. The starting contactor ST is energized by STZ of the generating unit selected by STS.

STD (TD), STARTING RELAY, Fig. 2-24

The starting relay STD ensures that reduced voltage is applied to the starting motors during the first 4.2 seconds of cranking.

During the first 1.2 seconds of cranking STRB shorts out a portion of the starting resistor to obtain high torque for initial movement of the pistons. After the first 1.2 seconds of cranking, STRB contacts open inserting more resistance in the starting circuit for slow cranking. Slow cranking continues for 3.0 seconds, then STR contacts close shorting out all the starting resistance and applying full battery voltage to the starting motors. Applying reduced voltage to the starting motors for 4.2 seconds results in slow cranking during the first revolution of the engine. The slow cranking prevents engine damage in case fluid is trapped in an engine cylinder. The STD contacts have an operating time delay of 3.0 seconds. STD is energized by closure of STRC contacts.

STR, STARTING RELAY, Fig. 2-24

The purpose of starting relay STR is to short out the starting resistor RE ST, applying full battery voltage to the starting motors, after the 4.2 seconds of slow cranking. STR is energized by closure of STD contacts.

STRA, STARTING AUXILIARY RELAY, Fig. 2-25

The starting auxiliary relay STRA opens the circuit to idle solenoid GS-1 allowing GS-1 to advance the fuel injectors to the idle speed setting, after 4.2 seconds of slow cranking. Prior to pickup of STRA, GS-1 is energized holding the fuel injectors at the fuel cutoff position. STRA is energized by closure of STD contacts.

STRB, STARTING AUXILIARY RELAY, Fig. 2-24

The starting auxiliary relay STRB shorts out a portion of the starting resistor RE ST to obtain high torque for initial movement of the pistons. After 1.2 seconds of high starting torque, STRC contacts open de-energizing STRB and inserting full starting resistance in the starting circuit for slow cranking.

STRC (TD), STARTING AUXILIARY RELAY, Fig. 2-24

The starting auxiliary relay STRC de-energizes STRB ending the 1.2 second high torque cranking period and to energize STD, starting the 3 second slow cranking period. STRC is energized by closure of STZ and ST contacts. STRC contacts have an operating time delay of 1.2 seconds.

STS, START STEPPING SWITCH, Fig. 2-24

The start stepping switch STS completes a circuit from the battery, located in the MPA unit, through STY contacts and a set of STS contacts to the starting circuit of a "ready to start" unit. It consists of an operating coil, an actuating lever, a set of interrupter contacts, and six sets of operating contacts. The starting control circuit of each generating unit, in the MU plant, is connected to a different set of the operating contacts. Only one set of operating contacts can be closed at any given time.

When STS picks up, the actuating lever retracts and the interrupter contacts open. When STS drops out, the interrupter contacts close and the actuating lever is released. Releasing the actuating lever causes STS to step, closing the next set of operating contacts. By picking up and dropping out, STS steps from unit to unit until the starting circuit of a "ready to start" unit is connected to the battery.

When a "ready to start" unit is selected, the immediate response contacts of STY opens to prevent STS from stepping to the next unit until a starting attempt has been made on the selected unit. When the selected unit has started and reaches a speed of 200 RPM, STY drops out permitting STS to step to the next unit. If the starter pinion engages, but the engine does not start within 15 seconds, a SEQUENCE fault is indicated and the unit is locked out, STS steps to the next unit. If the starter pinion does not engage within 2 seconds after the starting circuit is energized, STY drops out closing the immediate response contacts of STY which energizes STS permitting STS to step to the next unit. This stepping sequence continues until all units are started or locked out. A unit lockout, due to failure of starter pinion engagement, does not occur until after three attempts to engage the pinion.

STX (TD), STARTING RELAY, Fig. 2-24

Starting relay STX provides a short time delay in pickup of STS, permitting STY to open before STS is energized. This delay prevents STS from stepping past a "ready to start" unit. The contacts of STX have an operating time delay of 15 seconds.

STY (TD), STARTING RELAY, Fig. 2-24

The STY relay has one set of immediate response contacts and two sets of time delay contacts. The purpose of the immediate response contacts is to prevent pickup of STS when a "ready to start" unit is located. One set of time delay contacts initiate a sequence fault, if unit does not start within 15 seconds after the unit is selected for starting. The other set of time delay contacts permits STS to step to the next unit after 15 seconds of cranking. The time delay contacts of STY have an operating time delay of 15 seconds.

STYA, STARTING AUXILIARY RELAY, Fig. 2-24

Starting auxiliary relay STYA disconnects the control circuits and the battery charger from the battery, and connects the control circuits to the battery charger, during starting. This prevents overloading the battery charger, due to low terminal voltage of the battery during starting, and ensures sufficient voltage for proper operation of the control circuits.

STZ, STARTING CONTACTOR, Fig. 2-25

Starting contactor STZ sets up the pinion engaging circuit, by energizing M1 and M2 coils which thrust the pinion mechanism into the ring gear completing the circuit to starting contactor ST coil. STZ also sets up the SEQUENCE fault circuit and the starting relay STY circuit.

The STZ coil of only one unit can be energized at any given time. The selection of STZ is determined by STS.

T (TD), TIMER RELAY, Fig. 2-19

The timer relay T reduces over control of the shutters, thereby preventing continuous opening and closing of the shutters. It consists of an operating coil and two sets of contacts, one set of contacts being normally closed while the other set is normally open. Both sets of contacts have an operating time delay of 15 seconds for pickup and a time delay of 2 seconds for dropout. This arrangement provides 15 seconds for the temperature to stabilize between each 2 seconds of shutter movement.

TB, SHUTTER CONTROL TEMPERATURE SWITCH, Fig. 2-9

Shutter control temperature switch TB controls operation of the shutters as necessary to maintain water temperature in the temperature control manifold within the desired range of operating temperature.

TC, IMMERSION HEATER TEMPERATURE CONTROL SWITCH

This switch TC energizes IHC, through the normally closed contacts of ESR and OL RESET, when water temperature in the temperature control manifold drops below a predetermined value. Refer to description of IHC.

UR, UNIT READY RELAY, Fig. 2–25

The unit ready relay UR activates the starting selection circuit, the pinion failure relay PF, the pinion failure stepping switch PFS, and the starting contactor STZ.

USA, UNIT START RELAY, Fig. 2–25

The unit start relay USA activates the starting control circuits, provided a normal lockout signal is not present. USA is energized by pickup of NLO, LTR, or USR, and AR or IRE.

USD (TD), UNIT START RELAY, Fig. 2–25

The unit start relay USD has an operating time delay which holds the engine at idle speed for 90 seconds after starting, then picks up GS-II which causes engine speed to increase slightly above 900 RPM.

USR, UNIT START RELAY, Fig. 2–25

The unit start relay USR picks up USA when a start signal is received and drops out USA when a stop signal or a normal lockout signal is received. Operation of USR may be controlled from a remote START-STOP switch of by START-STOP switches located in the unit and in the outdoor switchgear station.

WARNING: After a start signal is received, USR remains energized until the STOP pushbutton is pressed. If the unit is shut down by a fault signal, the unit will automatically restart as soon as the fault is corrected and the annunciator RESET pushbutton is pressed, unless the STOP pushbutton has been pressed.

UST (TD), UNIT SHUTDOWN RELAY, Fig. 2–25

This relay UST allows the engine to idle for 11.5 minutes after a normal shutdown signal is given. The idle period permits gradual cooling of the engine and turbocharger prior to shutdown. An engine fault, engine overspeed trip, or a manual stop signal overrides UST and causes the engine to stop immediately. UST has an operating time delay of 11.5 minutes.

ZSR (TD), ZERO SPEED RELAY, Fig. 2–25

The zero speed relay ZSR is energized by pickup of RE1 relay, on the speed sensing panel, when engine speed increases to 40 to 50 RPM. After pickup, ZSR remains energized through RE1 contacts and ZSR contacts until the engine stops and RE1 drops out.

Pickup of ZSR results in pickup of ZSRA. The time delay contacts of ZSR keeps ZSRA energized for 2 seconds after ZSR drops out. Relay ZSRA prevents pinion engagement unless the engine is stopped.

ZSRA, ZERO SPEED AUXILIARY RELAY, Fig. 2–25

The zero speed auxiliary relay ZSRA is picked up by ZSR. Relay ZSRA prevents any attempt at pinion engagement until at least 2 seconds after the engine stops turning.

SECTION 8

ANNUNCIATOR OPERATION AND TROUBLE SHOOTING

This section provides a description of annunciator operation and a check list of areas to be investigated and corrections to be made in the event that operating difficulties are encountered. No attempt has been made to explain the normal mechanical or electrical functions. For such information refer to other sections of this manual and to the Engine Maintenance Manual.

ANNUNCIATOR

The annunciator, Fig. 2-22, is located on a door of the Electrical Control Cabinet. It contains neon bulb target lights that go on when annunciator relays are tripped by electrical or mechanical faults. Certain fault lights are indication of conditions that have caused the unit to shut down and lock out, while other lights provide warning only.

Provision is made for remote annunciator reset from the utility system's control location. Operation of the remote reset pushbutton will reset all corrected faults except, ENGINE, engine overspeed, and manual STOP.

ANNUNCIATOR RELAY OPERATION

Each protective device, when actuated, gives a signal to energize the operating coil "O" (trip) of its own annunciator relay. When actuating signal is removed, the operating coil is de-energized, but the relay remains latched in the tripped position until the reset coil "R" is energized and the fault signal is removed. The relay cannot be reset or it will not remain reset if the fault has not been corrected.

Certain annunciator relays, in addition to giving a visual indication, will interrupt the circuit to the normal lockout relay NLO. When NLO is dropped out, the unit will go off the line and the engine will either stop immediately or will idle for a timed period before total shutdown.

TROUBLE SHOOTING

Since most operating difficulties will be detected by annunciator operation, trouble shooting will usually start by observation of the annunciator indicator panel. The operation of each annunciator target and its possible causes will be described individually, see Fig. 8-1.

1. Fuel Transfer - FT, is a fault that causes an annunciator light display, but brings about no action other than the light signal. Action that does occur when this fault is registered is caused by the fault itself or by devices apart from the annunciator.

2. Faults that cause normal lockout, or shutdown and normal lockout with a timed idle period before the engine stops are:

   a. Engine Temperature - ET.

   b. Generator Breaker - GB.

   c. Sequence - SEQ.

3. Engine - EN, is a fault that will cause an immediate shutdown and lockout.

DIFFICULTIES SIGNALED BY THE ANNUNCIATOR

FUEL TRANSFER - FT

The FUEL TRANSFER light indicates an abnormally high or low day tank level. Trip of the FT relay causes the light to come on, but it does not affect engine operation. The annunciator may be reset when day tank level returns to normal.

Possible Causes Of Fuel Transfer Fault:

1. Fuel level in day tank too high.

   a. FTC contactor stuck closed.

   b. FTSN or FTSH float switch defective.

2. Fuel level in day tank too low.

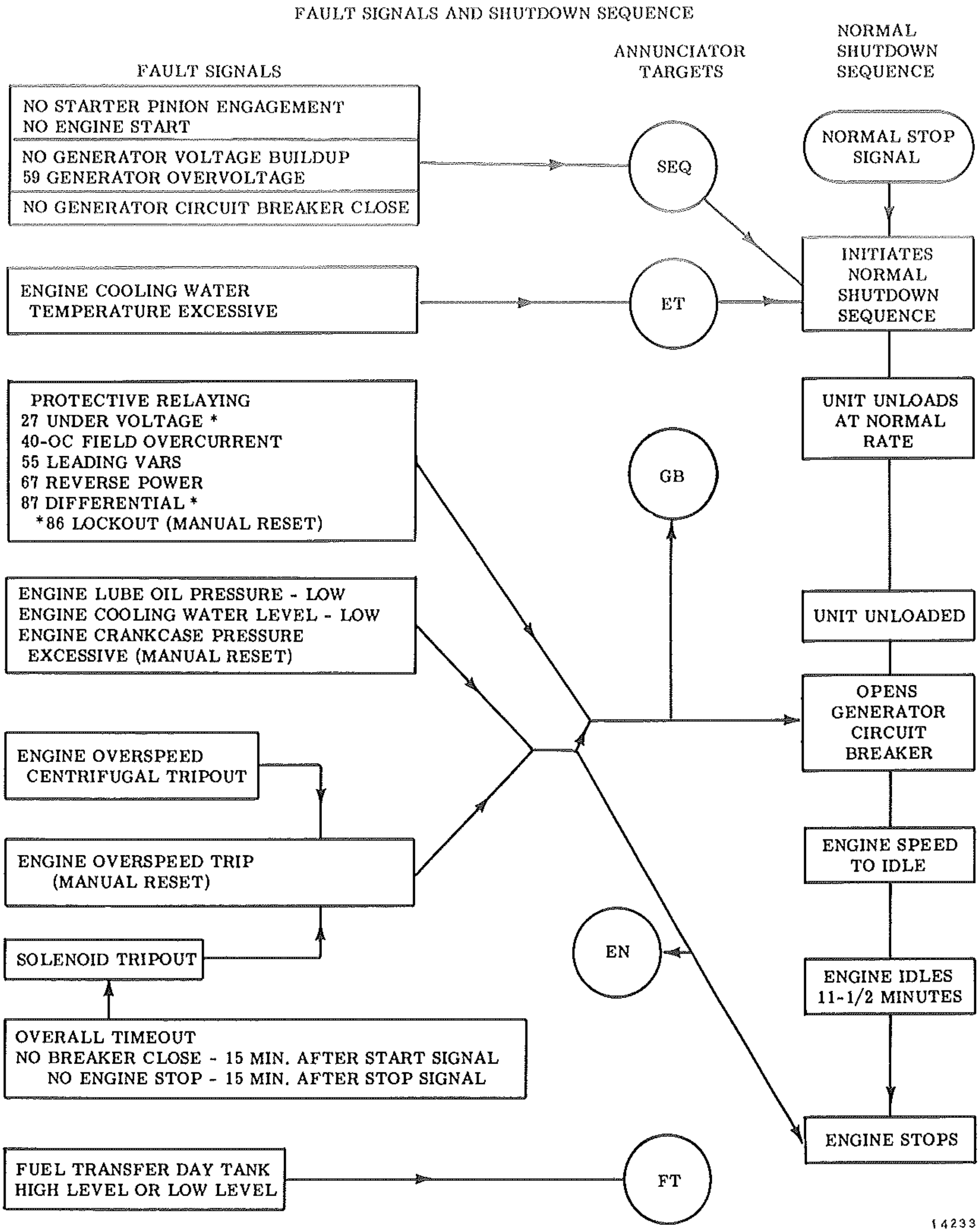


Fig. 8-1 — Fault Signals And Shutdown Sequence

a. Both fuel pumps inoperative or not energized.

b. Fuel transfer switch on the engine control panel of the unit equipped with fuel transfer pumps may be in OFF position or fuel transfer fuses may be blown.

c. FTSN or FTSL float switches defective.

d. Fuel transfer pump strainers or filter may be plugged. A plugged strainer or filter causes the motor to become overloaded. A thermal overload switch, located inside the end housing of the motor will open to de-energize the motor. Repeated overloading of the motor may result in a burned out motor. The thermal overload switch automatically resets when temperature of the switch returns to normal.

e. FTC contactor defective.

f. A valve in the fuel supply line may be closed.

g. Main supply tank may be empty.

h. Fuel piping may be plugged, broken or frozen. Plugged or frozen fuel piping may result in failure of the fuel oil transfer pump motor, due to overload.

i. Pour point of fuel should be at least 10° F. lower than the lowest expected ambient temperature. Using fuel with a pour point that is too high may result in failure of the fuel oil transfer pump motor, due to overload.

SEQUENCE – SEQ

The SEQUENCE light indicates any abnormal condition existing during the starting operation sequence. When the SEQ relay is tripped it will cause the light to come on and initiate a normal shutdown sequence.

Possible Causes Of Starting Failure:

1. If engine does not rotate –
   a. Starting fuse blown or removed.
   b. Defective cranking motor or solenoid.
   c. Starting sequence circuit fault. Check starting sequence fuse and relays.
   d. Hydraulic lock. Cylinder filled with fluid.
2. If engine rotates, but does not fire –
   a. No fuel supply to engine. Fuel should appear in the return fuel sight glass (nearest the engine), but not in the bypass sight glass. Check for plugged fuel oil strainer or plugged engine mounted fuel oil filters. Check for normal day tank fuel level. Refer to Section 2 and the Engine Maintenance Manual for more information on the fuel oil system.
   b. Governor solenoid GS-1 energized. Check for defective UST or STZ relay.
   c. Engine rotates slowly only. Check for defective ST contactor, or defective relays STD or STR. The time setting of STD may be incorrect.
   d. Injector fuel control rack binding.
   e. Emergency fuel cutoff valve closed.
   f. Governor oil level low (not visible in sight glass).
   g. Governor accumulator booster oil pump not operating.
   h. Overspeed lever tripped. Check for defective OTLS or OTL.

Possible Causes Of Voltage Failure:

1. No power to the static exciter.

   a. Control unit bus de-energized (peaking mode).

   b. Deadline field flashing system trouble (deadline mode).

   c. Controls not in correct position for desired mode of operation (peaking or deadline).

   d. Control power circuit breaker tripped.

   e. Control power transformer high voltage fuse defective.

   f. Field excitation fuse in fuse panel defective.

2. Exciter contactor EXC not closed.

   a. Excitation relay ER on unit control panel not picked up.

   b. Engine speed relay ES-87 not picked up.

3. Incorrect voltage regulator operation.

   a. Voltage regulator fuse defective (on regulator panel).

   b. High or low voltage generator metering power transformer fuses defective. (Located in and above the circuit breaker compartment.)

   c. Faulty voltage regulator.

4. Static exciter faulty.

ENGINE TEMPERATURE – ET

The ENGINE TEMPERATURE light indicates that the temperature of the coolant leaving the engine is approaching the boiling point while the engine is running at full speed.

The ENGINE TEMPERATURE annunciator relay brings the generating unit to a normal stop and lockout after a timed idle period. The light goes out when the annunciator is reset.

Possible Causes Of An Engine Temperature Light:

1. Broken fan belts.
2. Radiator air passages plugged.
3. Defective timer relay or shutter control temperature switch.
4. Defective shutter operation.
5. Plugged radiator core.

It is possible to reset the annunciator while the engine is idling before shutdown, but no attempt should be made to place the unit on the line until the cause of the hot engine has been determined and corrected.

GENERATOR BREAKER – GB

The GENERATOR BREAKER light indicates that the 52 circuit breaker was tripped open during operation under load; that is, automatic unloading and dropout of the master relay MR did not occur before the breaker tripped open. If the ENGINE light is displayed along with the breaker light the unit will have undergone immediate shutdown and lockout, and trouble shooting should center on the cause of engine alarm.

Possible Causes Of Generator Breaker Light With Normal Shutdown And Lockout:

1. Manual 52 circuit breaker control switch trip during automatic operation.
2. Differential relay 87 trip. Manual resetting of the 86 switch is required.
3. Reverse power relay 67 trip. Target will appear on the 67 relay.

4. Leading var relay 55 trip. Target will appear on the 55 relay. This may happen if generator excitation fails during operation.

5. Field overcurrent relay 40-OC pickup.

6. Under voltage relay 27 pickup.

7. Overvoltage relay 59 pickup.

Possible Causes Of Engine And Generator Breaker Light With Immediate Engine Shutdown:

1. Engine oil pressure failure.

2. Cooling water pressure failure.

3. Excessive crankcase (oilpan) pressure.

Tripping of the engine overspeed mechanism will also cause the generator breaker and engine light to come on and immediate engine shutdown. This may be caused by a true engine overspeed at approximately 10% over synchronous speed or by failure of the generating unit to complete a normal sequence causing pickup of the overspeed trip solenoid OTS. Overspeed trip action causes immediate trip of the 52 circuit breaker and the unit shuts down and remains locked out. The overspeed trip lever located at the camshaft must be manually reset, before the annunciator relay can be reset.

Possible Causes Of True Engine Overspeed Trip:

1. Sticking injector racks.

2. Improper governor operation.

   a. GOV95 switch set for too high speed, causing overspeed when load is suddenly dropped.

3. Air box flooded with lube oil.

Possible Causes Of Overspeed Trip Solenoid Action:

1. Failure of 52 breaker to close within a set time after engine start.

2. Failure of engine to stop within a set time after a stop signal is given.

   a. Injector rack stuck.

   b. Unit shutdown timer UST or overspeed trip time delay relay OTT improperly timed.

3. Failure in the peaking mode to load after a set time.

4. Improperly set ES87 pickup causing failure of starting cycle completion.

ENGINE - EN

The ENGINE light indicates that one of the following three faults has occurred.

1. True lube oil pressure failure.

2. Positive crankcase (oilpan) pressure.

3. Low water pressure.

When the engine annunciator relay trips, the generating unit main circuit breaker trips open and the engine stops immediately and is locked out. There is no timed idle before shutdown and lockout. The annunciator may be reset after the engine has stopped, but the cause of the shutdown should be determined before attempting further operation.

WARNING: Do not open oil pan inspection covers if a crankcase pressure trip has occurred and there is evidence of an overheated engine. Hot oil vapors resulting from a hot bearing or other part can ignite with explosive force if air is admitted to the oilpan.

Possible Causes Of Low Oil Pressure:

1. Oil supply low - below dipstick "low" mark with engine running. If the oil level is checked with the engine stopped a false reading will be obtained.
2. Broken or leaking oil line.
3. Fuel dilution of lube oil.
4. Plugged lube oil filters or strainers.
5. Plugged lube oil cooler resulting in hot, thin oil.
6. Oil foaming.

Possible Causes Of Positive Crankcase Pressure:

1. Broken piston.
2. Broken piston rings.
3. Faulty oil separator operation.
   a. Plugged oil separator.
   b. Leaking separator pipe.
   c. Saturated oil separator (resulting from oil foam due to excessively high oil level in the oilpan).
   d. Plugged or broken air box drain line or crankcase ejector assembly.
4. Air box pressure in oil pan.
   a. Missing or broken lower liner seals.
   b. Broken top deck oil drain tube.
   c. Broken air box drain tube.
   d. Loose, broken, or missing crankcase bolt.
5. Oil pan explosion.
6. Faulty or improperly applied oil pressure relief valve releasing oil on crankcase pressure sensing diaphragm.

Possible Causes Of Low Water Pressure:

1. Loss of engine water.
2. Cavitation at water pump inlet.
   a. Plugged oil cooler.
   b. Piping from water tank to pump inlets plugged or disconnected.
3. Defective water pump.

DIFFICULTIES NOT SIGNALED BY THE ANNUNCIATOR

Some operating difficulties may be encountered which do not result in an annunciator fault indication. Some can be detected before they become serious enough to warrant annunciator operation.

Defective Annunciator System

A defect in the annunciator system can create unusual operation problems. For example, a defective annunciator fuse will prevent any target lights from lighting, and the annunciator can not be reset. However, this will not prevent a unit lockout in the event of another operating difficulty.

Annunciator system trouble can best be prevented by periodic checks of the various alarm circuits.

Lack Of Power

Should the engine start, respond to control, and apparently function properly, yet does not have proper power, a thorough check of the following items should be made.

1. Insufficient fuel. Check fuel oil system for proper operation.
   a. Return fuel sight glass (glass nearest engine) should be full, clear and free of bubbles.

b. Bypass sight glass should contain no more than a trickle of fuel.

c. Pour point of fuel should be at least 10° F. lower than the lowest expected ambient temperature.

2. Insufficient air.

a. Body air filters clogged with leaves or other matter.

b. Engine air filters clogged.

c. Faulty turbocharger operation. Excessive exhaust back pressure.

3. Improper governor settings and adjustments.

a. GOV 95 switch setting too low.

b. GOV RS switch setting too low.

4. Load computer improperly calibrated (deadload operation).

EXHAUST SMOKE ANALYSIS

When engine is properly adjusted and is operating at the recommended working temperature, there should be no appreciable exhaust smoke. However, when first starting the engine or after a prolonged period of "no load", blue or gray smoke may be noticed. This will clear up after a short time if operation is normal. Continuous exhaust smoke should be investigated as follows:

1. Black or gray exhaust smoke indicates incompletely burned fuel.

a. Insufficient combustion air.

b. Excess fuel or irregular distribution. Check injector rack setting and timing, or for faulty injectors.

c. Improper grade of fuel. A fuel that is too heavy does not completely vaporize.

2. Blue exhaust smoke generally indicates lube oil entering the cylinder and being blown through cylinder during scavenging period. Check for internal fuel or lube oil leaks. (See next article on excessive lube oil consumption.)

3. White exhaust smoke indicates misfiring cylinders. Check for the following:

a. Faulty injectors.

b. Low compression.

c. Injector timing. See Engine Maintenance Manual for timing chart.

d. Exhaust valve clearance. See Engine Maintenance Manual.

e. Improper grade of fuel.

EXCESSIVE OIL CONSUMPTION

Some periods of high lube oil consumption are normal, such as break-in period of new power assemblies. In these cases added lube oil consumption will result until the oil control rings on the new assemblies have properly seated.

1. Lube oil leaks.

a. Oil lines and connections.

b. Gasket or seal leakage.

2. Oil control at cylinder.

a. Oil control rings worn, broken or improperly installed.

b. Scored liners or pistons.

APPENDIX

LEGEND OF DESIGNATIONS FOR ELECTRIC SWITCHGEAR AND CONTROL SYSTEM

Certain conventions are used to designate devices that are auxiliary to a primary or main device. These conventions take the form of numeral or letter prefixes or suffixes to the primary designation. The following is intended as a guide to understanding the use of auxiliary designations.

Auxiliary Switch Designations
(Such as 52a)

(a) Switch closed when device is in energized or operated position.

(b) Closed when device is in de-energized or non-operated position.

(aa) Closed when operating mechanism of main device is in energized or operated position.

(bb) Closed when operating mechanism of main device is in de-energized or non-operated position.

When several auxiliary switches are present on the same device, they shall be designated as 152a, 252a, etc.

Auxiliary Relay Designations
(Such as 40-OCX, 52 VX)

The auxiliary relay is generally operated by the basic relay contacts, or it is energized at the same time that the basic relay is energized.

NOTE: The practice of identifying a relay that operates in place of an auxiliary switch with the letters CL or OP is not followed.

The following list is provided to define numeral and letter designations used on the MU type power plant installation to identify equipment. In general the designations are in close agreement with industry standards. The designations appear on MU wiring diagrams and on tapes affixed to the specific equipment. Note however, that not all the designations presented are in use on individual MU installations, and that some installations may use designations not shown in the legend. Refer to the applicable wiring diagram legend.

To aid in locating a particular piece of equipment, the legend includes a letter or zone number shown adjacent to the equipment designation. This letter or zone number identifies equipment location as follows:

CB - Circuit Breaker

P - MP Type Generating Unit

SB - Switchgear Local Control Box

SC - Switchgear Cubicle

SP - Switchgear Cubicle Door Panel

ZONE NUMBERS
(See Fig. "Zone Identification")

Zone 25 - Engine Control Panel

Zone 45 - Starting Panel

Zone 55 - Sequence Control Panel

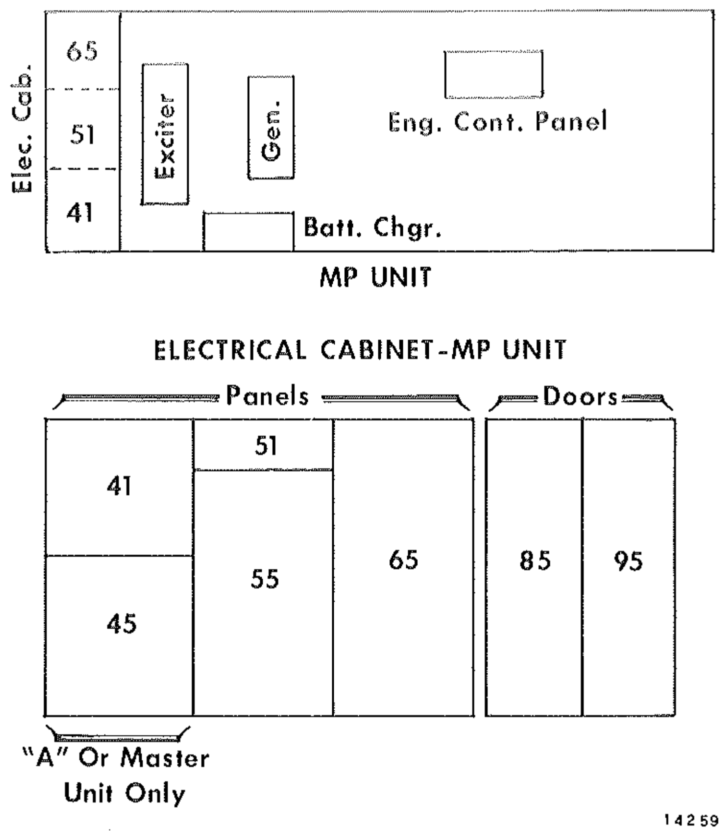
Zone 85 - Sequence Control Panel Door

Zone 41 - Master Extra Panel

Zone 51 - Unit Extra Panel

Zone 65 - AC Panel

Zone 95 - AC Panel Door



ZONE IDENTIFICATION

LEGEND	LOCATION	DESCRIPTION	LEGEND	LOCATION	DESCRIPTION
AR	55	Automatic Relay	DLR	41	Deadline Relay
CS	SP	Circuit Breaker Control Switch	DLS	41	Deadline Stepping Switch
DLB	41	Deadline Relay	DLT	51	Deadline Relay
DLBC	41	Deadline Breaker Close Relay	DLU	51	Deadline Relay
			DLX	41	Deadline Relay

LEGEND	LOCATION	DESCRIPTION	LEGEND	LOCATION	DESCRIPTION
DLZ	41	Deadline Relay	GS-1	P	Governor Solenoid - Idle Speed
EN	55	Engine Annunciator Relay	GS-2	P	Governor Solenoid - Synchronous Speed
ER	65	Excitation Relay	GV	65	Generator Voltage Relay
ERS	55	Excitation Relay	IHC	65	Immersion Heater Contactor
ERX	55	Excitation Relay	IRE	65	Idle/Run/Excitation Relay
ERY	55	Excitation Relay	LLR	65	Low Load Relay
ESF	45	Engine Speed/Fuel Transfer Relay	LTR	55	Low (Oil) Temperature Relay
ESR	55	Engine Speed Relay	LTRA	55	Low (Oil) Temperature Auxiliary Relay
ET	55	Engine Temperature Annunciator Relay	LOTS	55	Low Oil Temperature Switch
ETD	55	Exciter Time Delay Relay	LWS	25	Low Water Pressure Switch
ETI	85	Elapsed Time Indicator	MBR	55	Main Bearing Relay
ETS	P	Engine Temperature Switch	MBX	55	Main Bearing Relay
EXC	65	Exciter Contactor	MB-1	25	Main Bearing Switch
FFC	55	Field Flashing Contactor	MB-2	25	Main Bearing Switch
FFCO	85	Field Flashing Cutout Relay	MR	51	Master Relay
FSR	51	Fast Start Relay	MS	SP	Manual Switch
FT	45	Fuel Transfer Annunciator Relay	NLO	55	Normal Lockout Relay
FTC-1	25	Fuel Transfer Relay	OAD	55	Oil Alarm Delay Relay
FTC-2	25	Fuel Transfer Relay	OLT	51	Overload Timer Relay
FTM	P	Fuel Transfer Motor - Low/Normal	OTL	55	Overspeed Trip Limit Relay
FTSL	P	Fuel Transfer Switch - Low	OTLS	P	Overspeed Trip Limit Switch
FTSN	P	Fuel Transfer Switch - Normal	OTS	P	Overspeed Trip Solenoid
FTSH	P	Fuel Transfer Switch - High	OTT	55	Overspeed Trip Timer Relay
GB	55	Generator Breaker Annunciator Relay	PF	55	Pinion Failure Relay
GCS	SP	Governor Control Switch	PFS	55	Pinion Failure Stepping Switch
GN	SB	Governor Neutral Relay	PSR	41	Plant Start Relay
GOV RS	P	Governor Rack Switch - Open Above 200 KW			

LEGEND	LOCATION	DESCRIPTION
PTD	SB	Peaking/Transfer/ Deadload Switch
RE1	SSP	Engine Speed Relay
RE2	SSP	Engine Speed Relay
RS	41	Resynchronizing Relay
RSR	41	Resynchronizing Relay
RST	41	Resynchronizing Relay
RSU	51	Resynchronizing Relay
SC1	85	Deadline Overload Current Relay
SC2	85	Deadline Overload Current Relay
SEQ	55	Sequence Annunciator Relay
SS	SP	Start Stop Switch
ST	55	Starting Contactor
STD	45	Starting Relay
STR	45	Starting Relay
STRA	55	Starting Auxiliary Relay
STRB	55	Starting Auxiliary Relay
STRC	55	Starting Auxiliary Relay
STS	45	Starting Stepping Switch
STX	45	Starting Relay
STY	45	Starting Relay
STYA	45	Starting Auxiliary Relay
STZ	55	Starting Contactor
T	25	Timer Relay
TB	P	Shutter Control Temperature Switch
TC	P	Immersion Heater Temperature Control Switch
UR	55	Unit Relay

LEGEND	LOCATION	DESCRIPTION
USA	55	Unit Start Relay
USD	55	Unit Start Relay
USR	55	Unit Start Relay
UST	55	Unit Shutdown Relay
VR	65	Voltage Regulator
ZSR	55	Zero Speed Relay
ZSRA	55	Zero Speed Auxiliary Relay
27	SC	Under Voltage Relay
40-OC	65	Alternator Overcurrent Relay
40-OCX	55	Alternator Overcurrent Relay
52	CB	Main Generating Unit Circuit Breaker
52a	CB	Breaker Auxiliary Switch (Closed when breaker is closed)
52b	CB	Breaker Auxiliary Switch (Closed when breaker is open)
52TC	CB	Breaker Trip Coil
52V	55	Breaker Relay
52VM	45	Breaker Auxiliary Relay
52VX	65	Breaker Auxiliary Relay
52W	65	Breaker Auxiliary Relay
52WL	41	Load Breaker Relay
52WS	41	System Breaker Relay
55	85	Leading Var Relay
59	85	Overvoltage Relay
67	85	Reverse Power Relay
86	SP	Lockout Switch
87	SP	3 Phase Differential Protection Relay

TABLE OF FUSES AND CIRCUIT BREAKERS

ELECTRICAL CONTROL CABINET

ZONE 45 - STARTING PANEL

FUSE NUMBER	AMPERE RATING	CIRCUIT
F18, F19	30	Sequence Control
F20	10	Start Control
F21	15	Fuel Transfer Control
F22, F23	30	Fuel Transfer Motor
F24, F25	70	Switch Gear
F26	400	Master Start

ZONE 55 - SEQUENCE CONTROL PANEL

	10	Spare Fuse
F10	100	Field Flashing
F15	350	Starting
F16	10	Control

ZONE 65 - GENERATOR AND GOVERNOR CONTROL PANEL

F1	15	Shutter Control
F2	15	Lights
	6	Spare Fuse
F4, F5, F6	6	Potential Transformer
F7, F8, F9	1	Voltage Regulator
	100	Spare Fuse
F11, F12, F13	100	Exciter

OUTDOOR SWITCHGEAR

AUXILIARY SWITCHGEAR CUBICLE

QUANTITY	AMP.	NAME
3	6	Bus Metering Potential Transformer - low voltage
3	1 E	Bus Metering Potential Transformer - high voltage
3	40 E	Control Power Transformer - high voltage

GENERATOR SWITCHGEAR CUBICLE

2	30	Circuit Breaker Closing

CONTROL CIRCUIT BREAKERS

RATING	LOCATION
Control Power Circuit Breaker:	
400 Amp.	Outdoor Switchgear - Auxiliary Switchgear Unit
Space Heater and Lights Circuit Breaker:	
30 Amp.	Outdoor Switchgear - Auxiliary Switchgear Unit Door
Circulating Pump Motor Circuit Breaker:	
15 Amp.	Electrical Control Cabinet - Zone 85

GENERAL DATA

SPECIFICATIONS	TYPE OF UNIT 60 ∿ Peaking 8 Pole Gen.	60 ∿ Base Load 8 Pole Gen.	50 ∿ Base Load 8 Pole Gen.
Engine			
Model	20-645E4		
Type	2-Cycle, Turbocharged, "V"		
Number Of Cylinders	20		
Bore And Stroke	9-1/16 × 10 Inches		
Total Displacement, Cu. In.	12,900		
Compression Ratio	14.5:1		
Rating, BHP, Nominal	3600**	3600*	3050*
Operating Speed, RPM	900	900	750
Lubricating System	Full Pressure		
Governor (Woodward)	EGB-10		
Weight, Pounds (Engine Only)	Approximately 42,885		
Synchronous Generator			
Model	A20	A20	A20
KW	2750	2500	2100
KVA	3440	3125	2625
Phase	Three		
Volts	4160 Wye/2400 Delta		
Amperes	477/826	434/751	365/632
Power Factor %	Eighty		
Field Excitation			
No Load Amperes	39.2	39.2	55.0
Rated Load Amperes	105.1	97.67	120.79
Weight (Approximate)	18,100	18,100	18,100
Air Intake And Exhaust System			
Air Intake	Exhaust Driven Turbocharger		
Air Intake Filter-Carbody	Inertial Air Filter		
Air Intake Filter-Engine	Oil Bath		

*10% overload permissible for any 2 hours out of 24.
**Minimum load restricted to 20% of full load rating.

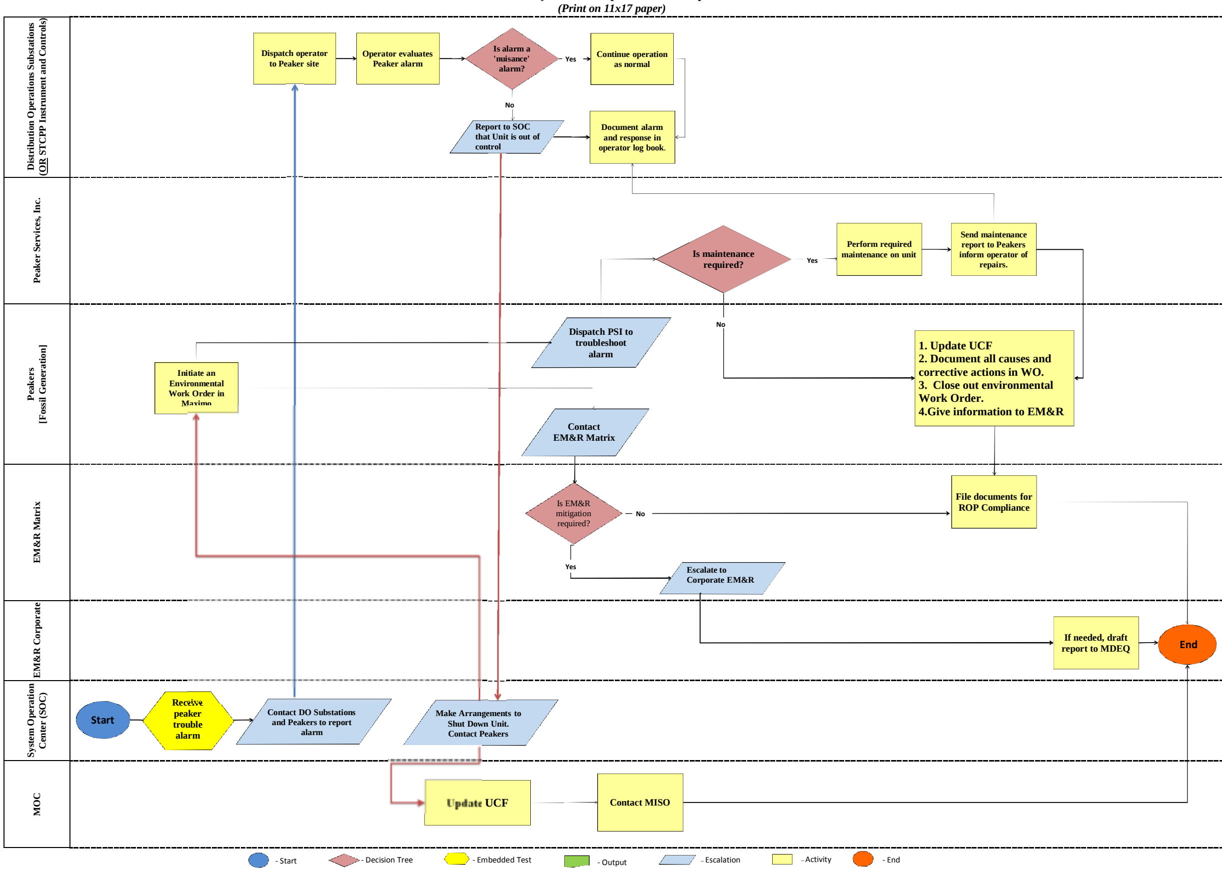
GENERAL DATA

SPECIFICATIONS	TYPE OF UNIT: 60 ∿ Peaking 8 Pole Gen.	60 ∿ Base Load 8 Pole Gen.	50 ∿ Base Load 8 Pole Gen.
Supplies - Each MP Unit			
Lube Oil - U.S. Gallons	466		
Operating Range - Gallons	230		
Cooling Water - Gallons	352		
Fuel Oil - Day Tank - Gallons	130		
Governor Oil Supply	2 U. S. Pints		
Immersion Heater			
Voltage	240		
Heater Elements	15 KW		
Lube Oil Circulating Pump	1 HP		
Pump Operation	Continuous		
Power Source	Control Transformer		
Dimensions And Weight - MP Unit			
Height - Shipping	12 ft. 0 in. Approx.		
- Installed	19 ft. 11 in. Approx.		
Width Over Eaves	10 ft. 4 in. Approx.		
Length - Installed	49 ft. 10 in. Approx.		
Approximate Weight			
- Less Supplies	128,300		
- With Supplies	136,000		
Dimensions And Weight - Outdoor Switchgear			
Height - Installed	9 ft. 0 in. Approx.		
Width - Installed	12 ft. 8 in. Approx.		

Outdoor Switchgear	MU 1	MU 2	MU 3	MU 4	MU 5
Length	5' 2"	7' 4"	9' 6"	11' 8"	13' 10"
Weight (lbs) - less aisle (Approx.)	6700	9700	12,700	15,700	18,700
Weight (lbs) - including aisle (Approx.)	8100	10,300	13,300	16,300	19,300

Appendix E - Peakers Catalyst Alarm Response Process Map

Peakers Catalyst Alarm Response Process Map - DRAFT
(Print on 11x17 paper)



Process Name	Process Owner Name	Process Inputs	Process Output Products	Output Metrics	Reference Documents
Peakers Catalyst Alarm Response Process Map					
Process Flow Number	Subject Matter Expert (Name)				
Revision Number / Revision Date	Key Stakeholders (Name)				
0 / 6/20/2012					

Appendix F - AST5100 Low Differential Pressure Transmitter

AST5100 Wet / Wet

Low Differential Pressure Transmitter

Overview

The AST5100 Wet - Wet Differential Pressure transmitter is your accurate pressure sensing device for low differential pressure. With a differential pressure range as low as 0 to 5" water column (12.5mbar), this product can be used to measure flow across an orifice, differential across a filter, tank level, or gauge pressure. Using LVDT technology and AST's advanced electronics, the AST5100 delivers accurate, repeatable measurements.

Benefits

- Accurate Low Pressure Measurement
- Excellent Repeatability
- Wide Range of Liquids and Gases including:
  Water, Natural Gas, Hydrocarbon Fuels, Air and Non-Corrosive Gases

Applications

- Liquid Level Control including Bubbler systems
- Climate Control
- Energy Management
- Air-fuel Ratio including Measurement for Furnaces
- Vapor Recovery
- Leak Detection
- Air or liquid Filtration
- Flow Measurement

Wetted Materials

Nickel Alloy 52, Ni-Span C, Viton, 304 Stainless Steel, Aluminum 6061, RoHS Solder, Loctite 680 (meets NSF61)

Performance @ 25°C (77°F)

Accuracy	<± 1.0% of FS
Stability	± 0.5%FS, typ
Line Pressure Max	200 PSI
Burst Pressure	2000 PSI
Pressure Cycles	>100,000 Cycles

Environmental Data

Temperature Range	
Operating Range	-40 to 80°C (-40 to 175°F)
Storage Temperature	-40 to 100°C (-40 to 212°F)
Thermal Limits	
Compensated Range	0 to 55°C (30 to 130°F)
Temp. Comp. Zero	<±1.5%
Temp. Comp. Span	<±1.5%
Other	
Reverse Polarity	Yes

Electrical Data

Output	**0-5V Three Wire**	**4-20mA**
Excitation	10-28VDC	10-28VDC
Output Change with Input Voltage Change	<0.1% from 10 to 32 VDC	-
Current Consumption:	< 10mA	-
Bandwidth	5Hz	5Hz
Output Noise:	< 1mV, RMS	< 0.0035mA, RMS
Zero Offset:	< ± 1% FS	< ± 1% FS
Span Tolerance:	< ± 1.5% FS	< ± 1.5% FS
Output Load:	5k Ohms, min.	0-800 Ohms@10-28 VDC

American Sensor Technologies - 450 Clark Dr., Mt. Olive, NJ 07828 - phone (973) 448-1901 - fax (973) 448-1905 - email: *info@astsensors.com*

Ordering Information

AST5100 J 00050H 4 Y 5 000

Series Type

Process Connection
J= 1/8" Female NPT

Pressure Range (See Chart)

Pressure Unit
H= Inches H_2O
P= PSI

Outputs
2= 0-5V 3-wire
4= 4-20mA

Electrical
Y= M12x1 Eurofast Connector

Wetted Material
5= Nickel Alloy 52, Ni-Span C, Viton, 304 Stainless Steel, Aluminum 6061, RoHSSolder, Loctite 680 (meets NSF61)

Options
000= No Special Options

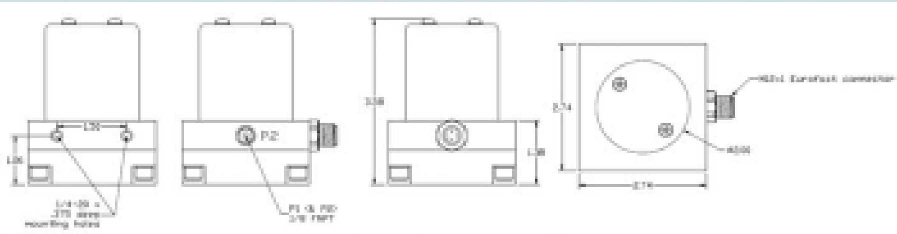
Mating PUR 22 AWG Cable Assembly	
Part Number	Cable Length
A10085	4 feet (1 m)
A10090	10 feet (3 m)

Pins	Conductor Colors	0-5V 3-wire	4-20mA
Pin 1	Brown	+V	+V
Pin 2	White	N/C	N/C
Pin 3	Blue	-V	-V
Pin 4	Black	V Out	N/C

Differential Pressure	Pressure Range Code	Proof Pressure (P1>P2)	Proof Pressure (P2>P1)
0-5 inch H_2O (12.5 mbar)	00005H	5 PSI	3 PSI
0-10 inch H_2O (25 mbar)	00010H	5 PSI	3 PSI
0-20 inch H_2O (50 mbar)	00020H	8 PSI	5 PSI
0-50 inch H_2O (125.5 mbar)	00050H	15 PSI	10 PSI
0-100 inch H_2O (249 mbar)	00100H	35 PSI	25 PSI
0-200 inch H_2O (498 mbar)	00200H	35 PSI	25 PSI
0-15 PSID (1034 mbar)	00015P	75 PSI	50 PSI

The over-pressure specification is the maximum pressure the AST5100 can see without damage. Any pressure applied over the listed numbers will likely damage the sensor and will, at minimum, cause a permanent zero shift. Over-pressure between 2X span and the numbers listed applied to port P1 will likely cause no permanent harm. Over-pressure of between 2X span and the numbers listed applied to port P2 may cause a temporary zero shift. To recover from a zero shift caused by negative over-pressure to P2 within the listed limits, apply a positive over-pressure P1 to just under the listed limit for a duration of 5 minutes. Remove the over-pressure and check the zero with no pressure applied. If the zero has not recovered, repeat the positive over-pressure and recheck zero. If it has not recovered after the second try, the zero has been permanently shifted. Contact the factory.

Dimensional Data



Installation Guidelines

The AST5100 must be mounted on a flat surface within ± 15° to the ideal 0° plane to maintain specifications. Do not Overtighten the pressure connections or insert any objects in P1 or P2 to avoid damaging the sensing element. When using isolation valves, both should be mounted close to the sensor. For liquid level and wet applications, install bleed screw adapters close to P1 and P2 so that trapped air can be purged if needed. For optimum performance, always make sure pressure is equalized within the pressure range chart ranges. The AST5100 has asymmetric protection on P1 and P2.

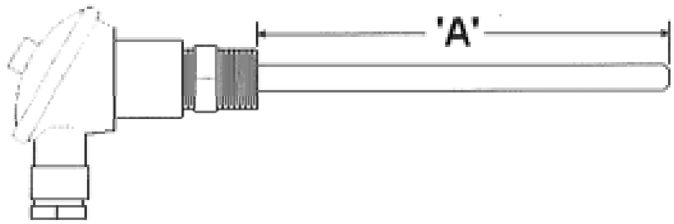
Warranty

Workmanship - AST, Inc. pressure transmitters have a limited one-year warranty to the original purchaser. AST, Inc. will replace or repair, free of charge, any defective transmitter. This warranty does not apply to any units that have been modified; misused, neglected or installed where the application exceeds published ratings. AST's sensors are made with pride in New Jersey, USA. If in the area please feel free to stop by for a visit!

Installation/Applications - The purchaser is responsible for media compatibility, functional adequacy, and correct installation of the transmitter.

Appendix G - Durosense Thermocouple

DATA SHEET



Customer	P.O. #	Order #	Part #
PEAKER SERVICES	VARIES	VARIES	MTC-H-37522-U-12-C-B

DESCRIPTIVE DATA	
CALIBRATION	K
ACCURACY	STANDARD LIMITS OF ERROR
JUNCTION	UNGROUNDED
SHEATH DIAMETER	.375"
ACTIVE LENGTH	12"
SHEATH MATERIAL	304 SS
PROCESS CONNECTION	½" NPT
COLD END TERMINATION	MINI HEAD WITH SINGLE TERMINAL BLOCK

TEMPERATURE RANGE / ACCURACY DATA		
TEMPERATURE RANGE	STANDARD LIMITS	SPECIAL LIMITS
-330°F TO -165°F	± 2%	-----
-165°F TO +32°F	± 4°F	-----
+32°F TO +545°F	± 4°F	± 2°F
+545°F TO +2300°F	± 0.75%	± 0.4%

RECOMMENDED TEMPERATURE LIMITS		
SHEATH DIAMETER	WIRE GAUGE	MAX. RECOMMENDED OPERATING TEMP.
.375" O.D.	13 ga. (nominal)	2150°F

Appendix H - Procedure Responding to Catalyst Alarm

DTE Electric
Peaking Unit Organization
POLICIES and PROCEDURES

Title: **Responding to Peaker Trouble Alarm – Diesel Oxidation Catalyst Alarm**	No: Env-01
Written By: Esmeralda Zamarron	Date: 05/02/2013
Approved By: *Nader N. Rajabian*	Date: 5/10/2013

1 REVISION HISTORY

Revision No.	Changes	Revised By	Authorization	Date
1	1. Added 6.2.3 "*Once an Alarm is received, Opertators must document the following:Date and Time of Alarm,Alarm Description, Actions taken to respond to alarm, Escalation steps taken to address alarm. If unit is shut down due to alarm condition, document what was done to bring the unit back into service. Time and date when alarm was cleared and back in service*". 2. Corrected numbering on section 6. 3. Changed header to DTE Electric	E. Zamarron	*N/A*	5/30/2013

2 PURPOSE

The DOC (diesel oxidation catalyst) installed on all diesel generators located at DO sites were installed in 2012-2013. The DOCs are designed to reduce the CO output of an EMD MP-45 by 70% or more.

The purpose of this procedure is to establish a process to respond to Diesel Oxidation Catalyst (DOC) Alarm and ensure continuous compliance with air regulations.

3 SCOPE

3.1 The scope of this procedure covers the response to a DOC alarm. The procedure identifies work groups from Distribution Operations, Generation Optimization, Peakers, and Peaker Services.

4 DEFINITIONS

4.1 DOC – Diesel Oxidation Catalyst

4.2 SOC – System Operations Center

4.3 PSI – Peaker Services Inc.

4.4 MOC – Merchant Operations Center

5 RESPONSIBILITIES

5.1 DO Operations – operates units, determines source of alarms, maintains detailed operator logs.

5.2 SOC – Remotely start units and dispatch DO operators as needed.

5.3 Peaking Unit Organization– provide maintenance services for peaking units and documents failures.

5.4 PSI – perform maintenance under the direction of the Peaking Unit Organization.

5.5 MOC – Update UCF and informs MISO.

5.6 Environmental Engineer – ensures ROP compliance for each peaking site.

6 PEAKER TROUBLE ALARM IS RECEIVED

6.1 SOC

6.1.1 SOC receives Peaker trouble alarm.

6.1.2 Dispatch operator to determine nature of alarm.

6.2 Operations

6.2.1 Arrives at site goes to Control House PLC to determine if the alarm was caused by a failure of the DOC system.

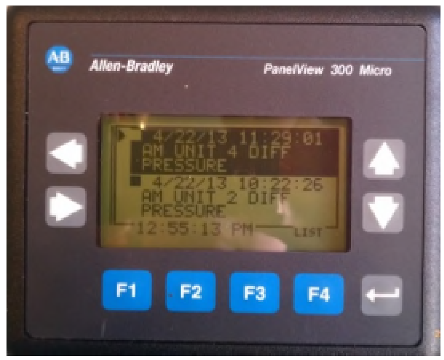
6.2.1.1 The control house PLC will display the DOC alarms along with the other unit alarms.

6.2.1.2 [F4] Select the F4 key, highlight the home screen option, and press enter [↵] to view the list of alarms.

6.2.1.3 The DOC alarm will list 3 pieces of information:

- The date and time of the alarm.
- The unit that has alarmed.
- The parameter that is out of bounds.

6.2.1.4 An example of a DOC differential pressure alarm on unit 4 is shown below. The alarm details are only accessible through the generator compartment PLC.



6.2.2 Operator determines that DOC is in Alarm

6.2.2.1 Operator informs the SOC regarding the alarm.

6.2.2.2 Operator makes arrangements to shut down unit that is in alarm

6.2.3 Operator documents actions taken to resolve the issues prior to returning the unit back to service.

6.2.4 Once an alarm is received, operator must document the following in the operator log book:

- Date and Time of Alarm
- Alarm Description
- Actions taken to respond to alarm
- Escalation steps taken to address alarm
- If unit is shut down due to alarm condition, document what was done to bring the unit back into service.
- Time and date when alarm was cleared and back in service.

6.3 SOC

6.3.1 Contacts Peaker Group and MOC regarding the shut down and unavailability of unit with DOC alarm.

6.4 MOC

6.4.1 Updates UCF when SOC communicates that unit is unavailable due to DOC alarm.

6.4.2 Informs MISO.

6.5 Peakers

6.5.1 Creates environmental work order to document alarm event.

6.5.2 Contacts PSI to trouble shoot unit and perform maintenance.

6.5.3 Communicates alarm event to Environmental Engineer.

6.5.4 Updates UCF when alarm is resolved and unit is returned to service.

6.5.5 Closes out environmental work order.

6.5.6 Provides all documents and information on the DOC alarm and response to Peaker Environmental Engineer.

6.6 PSI

6.6.1 PSI trouble shoots alarm and performs maintenance activities to return unit to service.

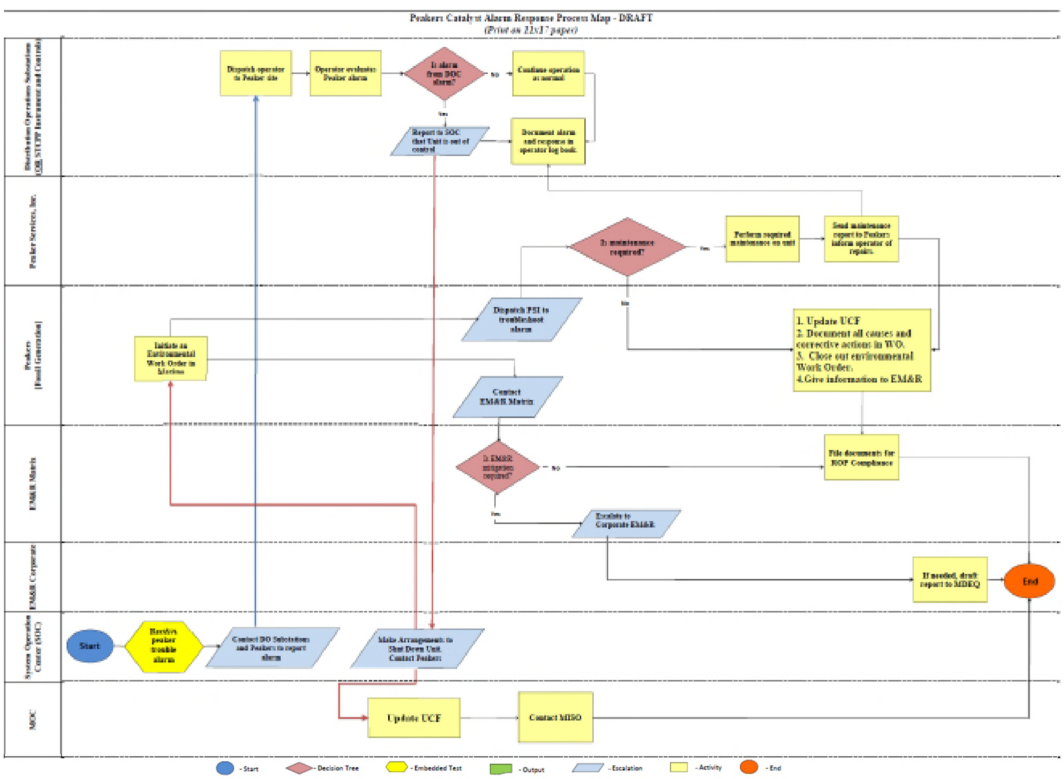
6.6.2 Provides repair report to Peakers.

6.7 Peaker Environmental Engineer

6.7.1 Determines if EM&R mitigation is required when alarm is initially reported.

6.7.2 Files documentation on DOC alarm for ROP compliance.

7 Process Map



8 Viewing alarm data in the Generator Compartment Dynalco PLC Instructions

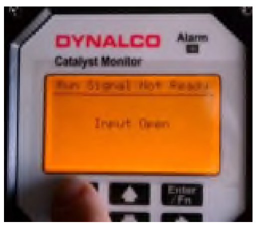
8.1 Background

Each unit has a PLC monitoring the temperature and differential pressure while the unit is running. If the DOC is not within its temperature and pressure parameters, the PLC will generate an alarm.

The PLC at the generator housing holds the official alarm record and all of the DOC's run data.

When the unit is running, the PLC displays cycles through the current DOC conditions.

When the unit is not running, the PLC display is as below.



8.2 Accessing Alarm Data

 Press the menu button.

 Use directional arrows to highlight the alarm icon. The resulting PLC display is displayed below.

 Press Enter to select the highlighted item. The resulting PLC display is displayed below.

Use directional arrows to highlight the Active Alarms option.

 Press Enter to select the highlighted line. The resulting PLC display is displayed below.

Use directional arrows to highlight either the temperature or differential pressure alarms.

Press Enter to select the highlighted line. The resulting PLC display is displayed below.

Use directional arrows to highlight select the alarm of interest.

Press Enter to select the highlighted line. The resulting PLC display is displayed below.