Malfunction Abatement Plan

FG-EG789 Engine Test Cells Thermal Oxidizer

Toyota Motor North America R&D
Ann Arbor, Michigan

Project No. 160141
July 5, 2018
Revised April 14, 2022




Fishbeck, Thompson, Carr & Huber, Inc.
engineers | scientists | architects | constructors

Malfunction Abatement Plan

FG-EG789 Engine Test Cells Thermal Oxidizer

Prepared For:
Toyota Motor North America R&D
Ann Arbor, Michigan

July 5, 2018
Revised April 14, 2022
Project No. 160141

39500 MacKenzie Drive, Suite 100
Novi, Michigan 48377
248.324.2090
www.ftch.com
Fishbeck, Thompson, Carr & Huber, Inc.
engineers I scientists I architects I constructors

Table of Contents

List of Tables

List of Appendices

List of Abbreviations/Acronyms

CO	Carbon Monoxide
°F	Degrees Fahrenheit
FG	Flexible Group
LEL	Lower Explosive Limit
MAP	Malfunction Abatement Plan
MDEQ	Michigan Department of Environmental Quality
N/A	Not Applicable
O&M	Operations and Maintenance
PTI	Permit to Install
ROP	Renewable Operating Permit
RTO	Recuperative Thermal Oxidizer
TMNA	Toyota Motor North America R&D
TO	Thermal oxidizer
UEP	Upper Explosive Limit

1.0 Introduction

This MAP has been prepared to comply with the Toyota Motor North America R&D (TMNA) ROP No. MI-ROP-N2915, *FG-CONTROLLED Special Condition III.1* and Rule 911. The purpose of this MAP is to define actions that will be taken at TMNA in the event of a malfunction of equipment, which could result in an exceedance of emission limitations.

Michigan Air Pollution Control Rule 911 specifies that, upon request of the MDEQ, a facility must prepare a MAP to prevent, detect, and correct malfunctions or equipment failures resulting in emissions exceeding any applicable emission limitation. Rule 911 states:

> *(1) Upon request of the department, a person responsible for the operation of a source of an air contaminant shall prepare a malfunction abatement plan to prevent, detect, and correct malfunctions or equipment failures resulting in emissions exceeding any applicable emission limitation.*
>
> *(2) A malfunction abatement plan required by subrule (1) of this rule shall be in writing and shall, at a minimum, specify all of the following:*
>
> *(a) A complete preventative maintenance program, including identification of the supervisory personnel responsible for overseeing the inspection, maintenance, and repair of air cleaning devices, a description of the items or conditions that shall be inspected, the frequency of the inspections or repairs, and an identification of the major replacement parts that shall be maintained in inventory for quick replacement.*
>
> *(b) An identification of the source and air cleaning device operating variables that shall be monitored to detect a malfunction or failure, the normal operating range of these variables, and a description of the method of monitoring or surveillance procedures.*
>
> *(c) A description of the corrective procedures or operational changes that shall be taken in the event of a malfunction or failure to achieve compliance with the applicable emission limits.*
>
> *(3) Malfunction abatement plan required by subrule (1) of this rule shall be submitted to the department and shall be subject to review and approval by the department. If, in the opinion of the commission, the plan does not adequately carry out the objectives as set forth in subrules (1) and (2) of this rule, then the department may disapprove the plan, state its reasons for disapproval, and order the preparation of an amended plan within the time period specified in the order. If, within the time period specified in the order, an amended plan is submitted which, in the opinion of the department, fails to meet the objective, then the department, on its own initiative, may amend the plan to cause it to meet the objective.*
>
> *(4) Within 180 days after the department approves a malfunction abatement plan, a person responsible for the preparation of a malfunction abatement plan shall implement the malfunction abatement plan required by subrule (1) of this rule.*

2.0 Defining Malfunctions

Rule 113(a) defines a malfunction as:

> *Malfunction means any sudden, infrequent and not reasonably preventable failure of a source, process, process equipment, or air pollution control equipment to operate in a normal or usual manner. Failures that are caused in part by poor maintenance or careless operation are not malfunctions.*

A true malfunction must have a reasonable potential to cause an exceedance of an emission or operational limit. Following is a list of malfunction events covered by this Plan.

- Failure of emission control system components (e.g., monitoring and data acquisition equipment.)
- Sudden and unavoidable failure of control or process equipment, not due to poor operation or maintenance procedures.

3.0 Emission Control Device

The CO emission control device consists of a Thermal Oxidizer (or TO).

4.0 Source Description

FG-EG789 consists of three engine test cells in the Evaluation Building controlled by a shared TO to provide at least 90% control of CO emissions.

Table 1 – Source Description

Emission Source	Control Equipment	Emissions Controlled
EU-EG7, EU-EG8, and EU-EG9	TO	CO

5.0 Responsible Personnel

The personnel responsible for elements of this MAP and a description of their respective responsibilities are summarized in Appendix 1. Appendix 1 will be updated as needed, and a copy of the updates will be maintained onsite. Changes to applicable personnel will be submitted to the MDEQ upon request.

6.0 Preventative Maintenance Program, Operational Variables, and Corrective Procedures

Preventative maintenance will include equipment inspections, scheduled replacement of parts, and maintaining an inventory of critical spare parts. The facility will track and maintain records of each preventative maintenance action completed. Equipment inspections generally fall under two categories: 1) inspections which take place while the facility is operating and 2) less frequent inspections which take place while the facility is not operating. The frequency and scope of the TO inspections will depend on the manufacturer recommendations and operator experience. Excerpts from the O&M Manuals for the TO fans and pumps are included in Appendix 2.

Contracts will be issued to outside vendors to conduct maintenance, repairs, and calibration, if necessary.

6.1 Items Inspected and Operational Variables

The facility is required to monitor and record the temperature in the TO on a continuous basis during operation of EU-EG7, EU-EG8, or EU-EG9. These temperature data recordings shall consist of measurements made at equally spaced intervals, not to exceed 15 minutes per interval. The data handling/monitoring system includes a new primary data recorder has been installed that communicates better with Toyota's software. A secondary (backup) data recorder was installed to ensure that data will be available if the primary recorder malfunctions in the future. The daily RTO check sheet was updated to include daily confirmation that the data recorders are satisfactorily monitored and recording data.

Table 2 provides general information regarding: 1) frequency of inspection and 2) normal operating ranges and monitoring of operational variables for the RTO.

Table 2 – Inspection Table and Operational Variables

Description of Observation	Method of Observation	Normal Operating Range	Frequency of Observation	Comments
TO Combustion Chamber Temperature	Thermocouple	Greater than 1,425°F	Continuous measurements of temperature are taken. Temperature is recorded at least once every 15-minutes in an electronic data recording system.	Data stored on network; in lieu of automated downloads, data will be manually download once per month
Data Handling System	Visual	Not Applicable	Daily observations to ensure that data is being recorded	Not applicable

If the temperature falls below the normal operating range the thermal oxidizer will alarm. The engines will automatically shut down if an RTO failure is detected and TMNA will initiate corrective action. If the weekly data handling/monitoring system check indicates issues with the monitoring system or data, Central Maintenance will be notified to correct the issue.

6.2 Corrective Action

If a malfunction occurs which causes, or may cause, excess emissions during plant operations, the equipment causing the potential excess emissions will be evaluated as soon as practicable, in accordance with safe operating procedures, to determine the proper procedure to correct the issue or to determine that the malfunction will not cause excess emissions. The Environmental Manager, or designated representative, in consultation with appropriate TMNA personnel will determine whether FG-EU789 can continue to operate consistent with good air pollution control practices to minimize emissions in compliance with permitted emission limits, until repairs can be made and/or before resuming normal operation.

The TO combustion chamber is equipped with a temperature thermocouple which continuously measures the temperature in the chamber. If the temperature in the chamber falls below 1,425°F, an alarm will sound and the test stands will automatically shut down. Corrective action will be initiated by TMNA, beginning with an evaluation of the occurrence to determine the action required to correct the situation.

In the event a malfunction is detected during a visual inspection, corrective action will be initiated, beginning with an evaluation of the occurrence to determine the action required to correct the situation. Corrective action

includes, but is not limited to: lubricating bearings, replacing or fixing the malfunctioning part, physical diagnostics by a trained technician, system bypass, and system shutdown. A TO Malfunction/Failure Report will be completed and submitted to the Environmental Manager.

In the event of a major malfunction, which could potentially damage the TO control system, the control system will be bypassed to ensure the operational reliability of the system. Such a bypass would only occur to the extent necessary to safely shut down FG-EU789. TMNA will keep a record of the frequency and duration of each bypass event.

See Appendix 3 for an example of the TMNA Thermal Oxidizer Malfunction/Failure Report.

6.3 Preventative Maintenance Records

The following records will be maintained for a period of five years:

- Inspections of the TO. Inspection records will include the date, findings, and corrective actions taken or repairs made, if necessary.
- All significant unscheduled maintenance activities performed on the TO. Records will include the date, findings, and corrective actions taken, or repairs made, if necessary.

6.4 Common Control System Malfunctions

Appendix 2 includes a list of trouble shooting areas for the hydraulic pumps. If a TO fault occurs the fault will be displayed on the screen. Table 3 identifies some common TO conditions, which were taken from the Ohio EPA Engineering Guide for thermal incineration.

Table 3 –Common TO Conditions/Corrective Actions

Failure Mechanism	Symptoms	Corrective Actions
Burner Fouling	High CO Insufficient combustion air Flame instability Flame out	Clean burner tips Prefilter ambient air Filter process stream Cease using process combustion air Improve fuel source
Preignition in heat exchanger	Decrease in carrier gas O_2 Leakage from fume side to flue gas side (bypass) Unexplained increase in outlet HC concentration	Reduce preheat temperature Retube heat exchanger
Thermal expansion (heat exchanger)	Tube failure Inleakage and bypass to flue gas side	Retube Conform to Manufacturer's recommended preheat schedule Limit maximum temperatures
Thermal expansion (oxidizer)	Refractory failure Shell failure due to heat stress	Repair refractory Limit maximum temperature and preheat rates Limit thermal cycling
Inleakage (rich system)	Decreased concentration of fume below UEL Potential for explosion	Periodic integrity check of transport system UEL monitors

Table 3 –Common TO Conditions/Corrective Actions

Failure Mechanism	Symptoms	Corrective Actions
Inleakage (lean system)	Decreased concentrations of fume below 25% of LEL Reduced capture volume at source	Periodic integrity check of transport system LEL monitor
In leakage (heat exchanger)	Increased stack HC concentration Tube failure	Retube HEX Limit temperature Excursions
HEX fouling	Decreased preheat temperature (i.e., delta T decreased) Increased stack temperature	Prefilter carrier gases Reduce heat exchanger temperature Eliminate preheat heat exchangers Clean heat exchangers
Refractory failure	Cracks Spalling Crumbing	Reduce cycling Limit peak temperature Post shutdown purge to remove corrosive gases
Draft control	Increased pressure drop Decreased capacity Decreased capture capacity	Reduce fouling Reduce combustion temperature Reduce transport air In leakage
Temperature control	Irregular combustion Temperature	Feedback temperature control system Dual temperature sensors
Slaging	Deposits in oxidizer Refractory failure Increased draft losses	Prefilter carrier gases Prefilter ambient combustion air
Flame safety	Flame out due to interlock protection Irregular flame	Inspect and replace sensor Relocate sensor's Position
Self-fueling	Increased temperature with no auxiliary fuel control	Vent to bypass Vent to flare

7.0 Major Parts Kept Onsite for Quick Replacement

See Appendix 4 for a list of electrical and mechanical spare parts kept onsite or can be ordered/received in a timely manner facilitating quick replacement.

Appendix 1

FG-789 & RTO ROLES & RESPONSIBILITIES

	RECORDKEEPING		DATA REVIEW		INSPECTIONS		
Role	**Track Fuel Usage 7, 8, 9**	**Track RTO Temperature (>1425F)**	**Monthly Permit Compliance**	**Compliance Reporting**	**Routine Inspection**	**PM Inspections**	**Equipment (on call)**
Powertrain Engine Test Stands	●	●	○				
Maintenance & Operations							
Central Maintenance					●	●	●
Outside Contractors							○
Environmental			●	●			
Safety							

MAP ROLES AND RESPONSIBILITIES

			MALFUNCTION RESOLUTION				
Role	**Malfunction Identification**	**Malfunction Notification**	**Corrective Actions**	**Repairs**	**Calibrations**	**Receive Final Report of Malfunction**	**MAP Regulatory Compliance to MDEQ**
Powertrain Engine Test Stands	●	●				○	
Maintenance & Operations		○				○	
Central Maintenance		○	●	●		○	
Outside Contractors		○		○	○		
Environmental		○	○			●	●
Safety					●		

● Lead ○ Support

Appendix 2

O&MManual_RTO_GasMeterSeriesB3ROOTS

INSPECTION AND MAINTENANCE

Maintenance for the Series 3 Accessory

IMPORTANT: NO oil is required for the Series 3 accessory unit.

The CTR, CD, ICEX, TC, TD and Solid State Pulser do not require scheduled maintenance.

To clean the Lexan® cover, use hot water and soap, mineral spirits, Isopropyl alcohol, or cleaning products approved for use on Lexan®.

IMPORTANT: Aromatics, Ketones, and Chlorinated hydrocarbons will damage the Lexan® cover. Do not use acetone, carbon tetrachloride, etc.

Meter Lubrication

Use only ROOTS® Meter Oil or other instrument grade oils approved for service by the manufacturer.

Meters installed and maintained in accordance with factory recommendations can be expected to operate dependably for many years. Proper oil level and cleanliness have the greatest effect on meter's life expectancy. Visually inspect the two oil reservoirs in the meter end covers for proper mid-gauge oil levels once a month until a practical interval is determined. Add oil as necessary.

Oil change frequency will depend upon the cleanliness of the gas being measured. Change oil when the color darkens or when the level changes. Under favorable conditions, these periods may be from 3 to 5 years, or longer.

CAUTION: THE METER END COVER IS PRESSURIZED.
Bleed off the line pressure before removing the oil fill or drain plugs from the meter.

DO NOT add oil to the Series 3 Accessory Unit.

Meter Level

Since the meter is supported entirely by the gas pipe line, movement of the piping due to accidents, settling of the ground or other causes may impede meter operation and accuracy. Refer to "INSTALLATION" procedures. Make sure the meter remains level within 1/16" per foot (5 mm/m) in any direction, side-to-side and front-to-back.

Cleaning and Flushing

NOTE: Before removing meter from the pipeline or performing this procedure, drain all oil from the meter end covers. Add oil after the meter has been replaced in the meter set.

After removing the meter from the line, if there is any evidence of dirt or dust in the meter, a suggested method for cleaning is to windmill the impellers (at a speed less than maximum capacity) by injecting low pressure, dry compressed air from a nozzle into the meter inlet. Flush approximately 5 ounces (150 ml) of an approved non-toxic, non-flammable solvent through the meter. Drain any residual cleaning fluid from the meter body and end covers. Use compressed air to completely dry the meter.

FAN MAINTENANCE

nyb fans are manufactured to high standards with quality materials and components. Proper maintenance will ensure a long and trouble-free service life.

Do not attempt any maintenance on a fan unless the electrical supply has been completely disconnected and locked. In many cases, a fan can windmill despite removal of all electrical power. The rotating assembly should be blocked securely before attempting maintenance of any kind.

The key to good fan maintenance is regular and systematic inspection of all fan parts. Inspection frequency is determined by the severity of the application and local conditions. Strict adherence to an inspection schedule is essential.

Regular fan maintenance should include the following:

1. Check the fan wheel for any wear or corrosion, as either can cause catastrophic failures. Check also for the build-up of material which can cause unbalance resulting in vibration, bearing wear and serious safety hazards. Clean or replace the wheel as required.
2. Check the V-belt drive for proper alignment and tension (see section on V-belt drives). If belts are worn, replace them as a set, matched to within manufacturer's tolerances. Lubricate the coupling of direct-drive units and check for alignment (see section on couplings).
3. Lubricate the bearings, but do not over lubricate (see the bearing section for detailed specifications).
4. Ceramic-felt shaft seals require no maintenance, although worn seals should be replaced. When lip-type shaft seals are provided, lubricate them with "NEVER-SEEZ" or other anti-seize compound

WARNING: Do not remove or loosen the fan hub from the fan wheel. Removing or loosening the fan hub from the fan wheel will cause imbalance and void the warranty.

BEARINGS

Storage

Any stored bearing can be damaged by condensation caused by temperature variations. Therefore, **nyb** fan bearings are filled with grease at the factory to exclude air and moisture. Such protection is adequate for shipment and subsequent immediate installation.

For long term or outdoor storage, mounted bearings should be regreased and wrapped with plastic for protection. **Rotate the fan wheel by hand at least every two weeks to redistribute grease on internal bearing parts.** Each month the bearings should be purged with new grease to remove condensation, since even a filled bearing can accumulate moisture. Use caution when purging, as excessive pressure can damage the seals. Rotate the shaft while slowly adding grease.

Operation

Check the setscrew torque before start-up (see table for correct values). Since bearings are completely filled with grease at the factory, they may run at an elevated temperature during initial operation. Surface temperatures may reach 180°F. and grease may bleed from the bearing seals. This is normal and no attempt should be made to replace lost grease. Bearing surface temperatures will decrease when the internal grease quantity reaches a normal operating level. Relubrication should follow the recommended schedule.

Disposal of material should be made in accordance to local government regulations.

Lubrication

Use the table for relubrication scheduling according to operating speed and shaft diameter. Bearings should be lubricated with a premium quality lithium-based grease conforming to NLGI Grade 2. Examples are:

Mobil	-	Mobilgrease XHP	Chevron	-	Amolith #2
Texaco	-	Premium RB	Shell	-	Alvania #2

These greases are for bearing surface temperatures of 40°F. to 180°F. For surface temperatures of 181°F. to 230°F. use Mobilith SHC220.

Do not use "high temperature" greases, as many are not formulated to be compatible with fan bearings.

Add grease to the bearing while running the fan or rotating the shaft by hand. Be sure all guards are in place if lubrication is performed while the fan is operating. Add just enough grease to cause a slight purging at the seals. Except on split pillowblocks. Completely filled bearings will run hotter until a sufficient amount of grease is purged out of the seals.

Split pillowblock bearings (Link-Belt P-LB6800 & P-LB6900, SKF SAF 22500, Dodge SAF-XT) should be cleaned and repacked at approximately every eighth lubrication interval. This requires removal of the bearing cap. Clean out old grease and repack the bearing with fresh grease. Pack the bearing fully and fill the housing reservoir to the bottom of the shaft on both sides of the bearing. Replace the bearing cap, being careful not to mix caps as they are not interchangeable from one bearing to another. **Do not over lubricate.**

BEARING LUBRICATION INTERVAL (months)

Shaft	RPM									
	1-500	501-1000	1001-1500	1501-2000	2001-2500	2501-3000	3001-3500	3501-4000	4001-4500	4501-5000
5/8 Thru 1	6	6	5-6	5-6	4-6	4-6	3-4	3-4	2	2
13/16 thru 1 7/16	6 / 6	6 / 4	5-6 / 4	4-6 / 2	4-6 / 2	3-5 / 1	2-4 / 1	2-4 / 1	1-2 / 1	1 / 1/2
1 11/16 thru 1 15/16	6 / 6	6 / 4	4-6 / 2	4-6 / 1	2-4 / 1	2-4 / 1	2 / 1/2	1-2 / 1/2	1-2	1
2 3/16	6 / 6	5-6 / 4	4-6 / 2	3-4 / 1	2-4 / 1	1-2 / 1/2	1-2	1-2	1	
2 7/16	6 / 4	4-6 / 2	4-6 / 1	3-4 / 1	2 / 1/2	1-2 / 1/2	1-2	1	1	
2 11/16 & 2 15/16	5-6 / 4	4-6 / 2	2-4 / 1	2 / 1	1-2 / 1/2	1	1	1		
3 7/16 thru 4 3/16	4-6 / 4	3-5 / 2	2-4 / 1	1-2 / 1/2	1	1	1	1		
4 7/16	4-6 / 4	4 / 1	2 / 1/2	1						
4 15/16	4-6 / 2	3-4 / 1	2 / 1/2							
5 7/16	6	4	2							
6	6	4								

Ball Bearings & Split Pillowblock Spherical Roller Bearings

Non-Split Pillowblock Spherical Roller Bearings

Note:

1. **These are general recommendations only; specific manufacturer's recommendations may vary slightly.**
2. **Assumes clean environment, -20°F. to 120°F.**
   a. **Consult The New York Blower Company for operation below -20°F. ambient.**
   b. **Ambient temperature greater than 120°F. will shorten bearing life.**
   c. **Under extremely dirty conditions, lubricate more frequently.**
3. **Assumes horizontal mounting configuration. For vertically mounted applications, lubricate twice as frequently.**

THE NEW YORK BLOWER COMPANY
7660 Quincy Street
Willowbrook, IL 60527-5530
Visit us on the Web: http://www.nyb.com
Phone: (800) 208-7918 Email: nyb@nyb.com

PRESSURE BLOWERS
TYPE HP PRESSURE BLOWERS

FAN MAINTENANCE

nyb fans are manufactured to high standards with quality materials and components. Proper maintenance will ensure a long and trouble-free service life.

Do not attempt any maintenance on a fan unless the electrical supply has been completely disconnected and locked. In many cases, a fan can windmill despite removal of all electrical power. The rotating assembly should be blocked securely before attempting maintenance of any kind.

The key to good fan maintenance is regular and systematic inspection of all fan parts. Inspection frequency is determined by the severity of the application and local conditions. Strict adherence to an inspection schedule is essential.

Regular fan maintenance should include the following:

1. Check the fan wheel for any wear or corrosion, as either can cause catastrophic failures. Check also for the build-up of material which can cause unbalance resulting in vibration, bearing wear and serious safety hazards. Clean or replace the wheel as required.
2. Check the V-belt drive for proper alignment and tension (see section on V-belt drives). If belts are worn, replace them as a set, matched to within manufacturer's tolerances. Lubricate the coupling of direct-drive units and check for alignment (see section on couplings).
3. Lubricate the bearings, but do not over lubricate (see the bearing section for detailed specifications).

4. Ceramic-felt shaft seals require no maintenance, although worn seals should be replaced. When lip-type shaft seals are provided, lubricate them with "NEVER-SEEZ" or other anti-seize compound.
5. During any routine maintenance, all setscrews and bolts should be checked for tightness. See the table for correct torques.
6. When installing a new wheel, the proper wheel-to-inlet clearance must be maintained (see Figure 3).

WARNING: Do not remove or loosen the fan hub from the fan wheel. Removing or loosening the fan hub from the fan wheel will cause imbalance and void the warranty.

Lubrication

Use the table for relubrication scheduling according to operating speed and shaft diameter. Bearings should be lubricated with a premium quality lithium-based grease conforming to NLGI Grade 2. Examples are:

Mobil	-	Mobilgrease XHP	Chevron	-	Amolith #2
Texaco	-	Premium RB	Shell	-	Alvania #2

These greases are for bearing surface temperatures of 40°F. to 180°F. For surface temperatures of 181°F. to 230°F. use Mobilith SHC220.

Do not use “high temperature” greases, as many are not formulated to be compatible with fan bearings.

Add grease to the bearing while running the fan or rotating the shaft by hand. Be sure all guards are in place if lubrication is performed while the fan is operating. Add just enough grease to cause a slight purging at the seals. Except on split pillowblocks. Completely filled bearings will run hotter until a sufficient amount of grease is purged out of the seals.

Split pillowblock bearings (Link-Belt P-LB6800 & P-LB6900, SKF SAF 22500, Dodge SAF-XT) should be cleaned and repacked at approximately every eighth lubrication interval. This requires removal of the bearing cap. Clean out old grease and repack the bearing with fresh grease. Pack the bearing fully and fill the housing reservoir to the bottom of the shaft on both sides of the bearing. Replace the bearing cap, being careful not to mix caps as they are not interchangeable from one bearing to another. **Do not over lubricate.**

BEARING LUBRICATION INTERVAL [months]

RPM / Shaft	1 - 500	501-1000	1001-1500	1501-2000	2001-2500	2501-3000	3001-3500	3501-4000
1 7/16	6 / 6	6 / 4	5-6 / 4	4-6 / 2	4-6 / 2	3-5 / 1	2-4 / 1	2-4 / 1
1 11/16	6 / 6	6 / 4	4-6 / 2	4-6 / 1	2-4 / 1	2-4 / 1	2 / 1/2	1/2 / 1/2
1 15/16			6	4-6	4	2-4	2	--
2 7/16	6	4-6	6	4-6	4	2-4	2	1-2
2 15/16	5-6	4-6	4-6	4-6	2-4	2	1/2	1
3 7/16	4-6	3-5	3-4	2-4	2-4	1-2	1	1

Ball Bearings → ◿ ← **Non- Split Pillowblock Spherical Roller Bearings**

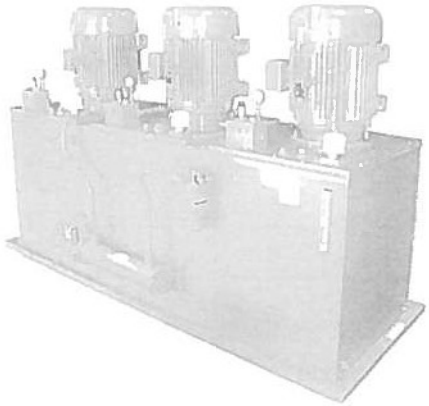
NOTE:

1. **These are general recommendations only; specific manufacturer’s recommendations may vary slightly.**
2. **Assumes clean environment, -20°F. to 120°F.**
   a. **Consult The New York Blower Company for operation below -20°F. ambient.**
   b. **Ambient temperatures greater than 120°F. will shorten bearing life.**
   c. **Under extremely dirty conditions, lubricate more frequently.**
3. **Assumes horizontal mounting configuration. For vertically mounted applications, lubricate twice as frequently.**

MFP AUTOMATION ENGINEERING

MFP Power Units

Revised: June, 2015



Custom Power Units Installation and Maintenance Manual

MFP AUTOMATION ENGINEERING

MFP Automation Engineering
4404 Central Parkway
Hudsonville, MI 49426 USA
Tel (616) 538-5700
Fax (616) 538-0888
Web Site: www.mfp.com

Table of Contents

Custom Hydraulic Power Units Installation Guide

MFP AUTOMATION ENGINEERING

MFP Automation Engineering
4404 Central Parkway
Hudsonville, MI 49426 USA

Troubleshooting Solenoid Valves (Cont.)

3) Has foreign matter jammed the main spool? (Remove end caps and see that main spool is free in its movement...remember that there will be a quantity of fluid escaping when the cap is removed and provide a container to catch it.)

4) Is pilot pressure available? Is the pilot pressure adequate? (Check with gauge on main pressure input port for internally piloted types and in the supply line to the externally piloted type.)

5) Is pilot drain restricted? (Remove pilot drain and let the fluid pour into an open container while the machine is again tried for normal operation. Small lines are often crushed by machine parts banging against them causing a subsequent restriction to fluid flow.)

6) Is pilot tank port connected to main tank port where pressures are high enough to neutralize pilot input pressure? (Combine pilot drain and pilot tank port and check for operation with the combined flow draining into an open container...block line to main tank from pilot valve...if this corrects the situation, reroute pilot drain and tank line.)

7) Are solenoids improperly interlocked so that a signal is provided to both units simultaneously? (Put test light on each solenoid lead in parallel and watch for simultaneous lighting...check electrical interlock. This condition probably burns out more solenoids than any other factor.)

8) Has mounting pad been warped from external heating? (Loosen mounting bolts slightly and see if valve functions. End caps can also be removed and check for tight spool.)

9) Is fluid excessively hot? (Check for localized heating which may indicate an internal leak...check reservoir temperature and see if it is within machine specifications.)

10) Is there foreign matter in the fluid media causing gummy deposits? (Check for contamination...make certain seals and plumbing are compatible with the type of fluid being used.)

11) Is an adequate supply of fluid being delivered to actuate the load? (Many times there is sufficient pressure to shift the valve but not enough to actuate the work load. Check pump supply pressure and volume if necessary...physical measurement of flow through relief valve with units blocked may be necessary.)

12) Check circuit for possible interlocks on pressure sources to valve or to pilot.

Introduction

This manual provides descriptive operation and maintenance instructions for Hydraulic Power Units manufactured by MFP Automation Engineering. Any additional information may be obtained from MFP by referencing the Unit's Model Number and Serial Number stamped on the Reservoir Nameplate.

Some of the Information in this manual may not apply to your power unit. Information on custom units may require service and application information from other sources.

Warning

It is imperative that personnel involved in the installation, service, and operation of the power unit be familiar with how the equipment is to be used. They should be aware of the limitations of the system and its component parts and have knowledge of good hydraulic practices in terms of safety, installation, and maintenance.

Description

The standard Hydraulic Power Unit usually consists of a JIC, "L" shaped, or vertical reservoir; all of which incorporate sump drain, oil level gage, filler/breather assembly and spare return connections. The pump will be coupled to the motor using either an integral close coupled configuration or flexible shaft coupling.

Customer type power units may have heat exchangers for oil cooling; pressure or return filters, oil immersion heaters, directional valves, and other pressure and flow control valves, or monitoring instrumentation.

Preparation for Use

Unpacking and Checking

The Power unit is mounted on skids and carefully packed for shipment. Do not remove it from the skid until it has been carefully checked for damage that may have occurred in transit. Report all damage immediately to the carrier and send a copy to the vendor. All open ports on the Power Unit were plugged at the factory to prevent the entry of contamination. These plugs must not be removed until just before piping connections are made to the unit.

Storage

If the Power Unit is not going to be installed immediately, it should be stored indoors, covered with waterproof sheet, and all open ports plugged. If long term storage is expected (6 months or more) we recommend filling the reservoir completely with clean hydraulic fluid to prevent the entry of moisture.

Removing from Shipping Skids

Vertical Power Units should be removed from the skid by wrapping a heavy duty nylon strap around the base of the motor mounting feet. This strap should be firmly secured to the lift truck forks when unit is lifted. Small horizontal style Power Units should be moved with a fork-lift truck, with 2 x 4 boards under the reservoir belly, to distribute and steady the load. Larger horizontal style Power Units have lifting holes in the reservoir end plates. Extra heavy 1 ½" pipes can be inserted into the lifting holes for allowing movement with a fork-lift truck. L-shaped reservoirs are provided with clearance and cross braces under the base plate for movement with a fork-lift truck.

Installation

Locating Power Unit

The unit should be installed indoors; and preferably in a clean, dry environment with an ambient temperature of 60 to 100°F. The unit can be installed outdoors if the reservoir was provided with optional weatherproof construction, and provisions were made for extreme temperature conditions. The reservoir can be secured to the floor or base using the four mounting holes located on the reservoir legs.

Service Connections

Water (If water cooled heat exchange has been provided) Connect the water supply to the inlet of the heat exchanger, with a shut-off valve and strainer (if not supplied by MFP). If a temperature Control Valve has been provided, it also should be installed on the inlet side. The outlet of the heat exchanger should be connected directly to the facility drain system. On single pass heat exchangers the water connections should be installed as shown below. On multi-pass heat exchanger the water flow direction is not important. (See fig. 1)

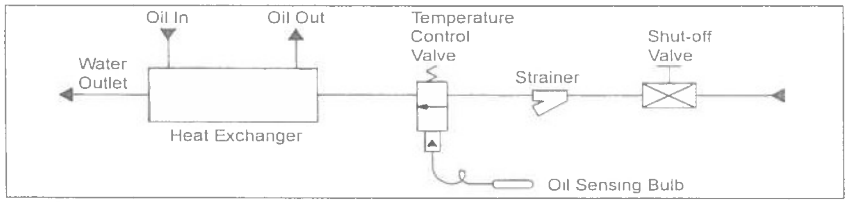


Figure 1

Service Connections (Cont.)

Electrical Connect the pump motor to the power source following the good practices as outlined in the National Electric Code and any local codes which may apply. Verify that the available voltage is the same as the voltage identified on the motor nameplate. Most motors have dual voltage ratings, so verify that the leads in the conduit box have been connected together as defined on the motor nameplate to match the facility power source available.

If Solenoid valves, pressure/temperature switches, or oil immersion heaters have been provided on the power unit, refer to the component name tag or other service information in this manual for operating voltage and ratings. If part number 0111-650 or 0111-651 temp/level switch was provided with the power unit, refer to diagram below for wiring requirements (Figure 2). If TLS-100 series temp/level switch was provided, refer to wiring diagram below (Figure 3).

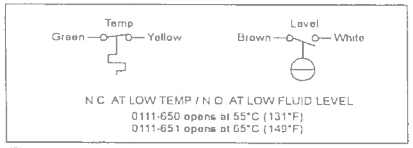


Figure 2

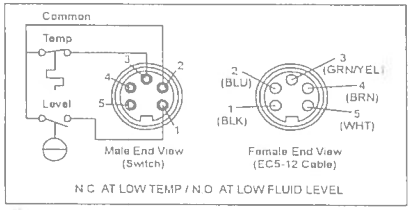


Figure 3

Supply and Return Connections

Complete all necessary interconnecting piping between the power unit and hydraulic actuators. The line sizes should be determined based on oil flow, operating pressure and allowable pressure drop between the power unit and actuator.

Warning

Check to insure that the proper rated hose or pipe is used on pressure lines.

One of the key ingredients for good service and long life from a hydraulic system is cleanliness, and since most dirt infiltrates a hydraulic system during installation, we recommend the following:

a) All open ports on the power unit, cylinders, etc. must remain plugged with tape or plastic plugs until just before the hydraulic connections are made.

b) All interconnecting tubing, pipe, or hose should be clean, and free of rust, scale and dirt. The ends of all connectors should be plugged until just before they are to be installed in the system.c) All openings in the reservoir such as the filler breather or access end covers holes must remain closed during installation.

d) If Teflon tape or pipe dope is used be sure it doesn't extend beyond the first thread of the pipe fitting.

Reservoir Filling

The reservoir must be filled with clean fluid thru the filler cap on the reservoir. The type of fluid must be compatible with the seals used on the power unit, and must comply with the recommendations of the manufacturers of the component parts.

Troubleshooting Pumps (Cont.)

16) Oil viscosity too high or operating temperature too low.

17) Air leak in suction line or fittings may cause irregular movement of hydraulic system.

18) Loose or worn pump parts.

19) Pump being driven in excess of rated speed.

20) Air leak at pump shaft seal.

21) Oil level to low and drawing air in through inlet.

22) Air bubbles in intake oil.

23) Suction filter too small or too dirty.

24) Suction line too small or too long.

25) Pump housing bolts loose or not properly torqued.

Pump failure to delivery fluid
1) Low fluid level in reservoir.
2) Oil intake pipe suction strainer plugged.
3) Air leak in suction line and preventing priming.
4) Pump shaft turning too slowly.
5) Oil viscosity too high.
6) Oil lift too high.
7) Wrong shaft rotation.
8) Pump shaft or parts broken.
9) Dirt in pump.
10) Variable delivery pumps (improper stroke).

Oil leakage around pump
1) Shaft seal worn.
2) Head of oil on suction pipe connection – connection leaking
3) Pump housing bolts loose or improperly torqued.
4) Case drain line too small or restricted (shaft seal leaking).

Excessive pump wear
1) Abrasive dirt in the hydraulic oil being circulated through the system.
2) Oil viscosity too low.
3) System pressure exceeds pump rating.
4) Pump misalignment or belt drive too tight.
5) Air being drawn in through inlet of pump.

Pump parts inside housing broken
1) Seizure due to lack of oil.
2) Excessive system pressure above maximum pump rating.

3) Excessive torquing of housing bolts.

4) Solid matter being drawn in from reservoir and wedged in pump.

Troubleshooting Solenoid Valves

Solenoid failures
1) Voltage too low. If voltage is not sufficient to complete the stroke of the solenoid, it will burn out the coil.
2) Voltage too high. Excessive voltage can also burn out coils.

3) Signal to both solenoids of a double solenoid valve simultaneously. One or both of the solenoids will be unable to complete their stroke and will burn out. (Make certain the electrical signal is interlocked so that this condition cannot exist).

4) Mechanical damage to leads. (Short circuit, open connections, etc.)

5) Tight spool or other mechanical parts of the valve being actuated can prevent the solenoid from completing its stroke and subsequently burning out.

6) Replacement springs too heavy in valve. Overloads solenoid and shortens life.

7) Dirty contacts may not supply sufficient current to solenoid to satisfy inrush demands.

8) Low voltage direct current solenoids may be affected by low battery capacity on cold mornings directly after starting cold engine. (DC)

9) Long feed lines to low voltage solenoids may cause sufficient voltage drop to cause erratic operation.

Solenoid valve fails to operate

1) Is there an electrical signal to the solenoid or operating device? Is the voltage too low? (Check with voltmeter...test light in emergency.)

2) If the supply to the pilot body is orificed, is the orifice restricted? (Remove orifice and check for foreign matter. Flushing is sometimes necessary because of floating impediment.)

Troubleshooting (Cont.)

Moisture in Oils
1) Cooling coils not below fluid levels.
2) Cold water lines fastened directly against hot tank causing condensation within the tank.
3) Soluble oil solution splashing into poorly sealed tanks or fill pipes left open.
4) Moisture in cans used to replace fluid in tanks.
5) Extreme temperature differential in certain geographical locations.
6) Drain not provided at lowest point in tank to remove water collected over possibly long operating periods.

Overheating of System
1) Relief valve set too close to compensator pressure setting.

2) Water shut off or heat exchanger clogged.

3) Continuous operation at relief setting.
   a. Stalling under load, etc.
   b. Fluid viscosity too high or too low.

4) Excessive slippage or internal leakage.
   a. Check staff leakage part pump, motors and cylinders.
   b. Fluid viscosity too low.

5) Reservoir sized too small.

6) Case drain line from pressure compensated pump returning oil too close to suction line.
   a. Re-pipe case drain line to opposite side of reservoir baffling.

7) Pipe, tube or hose I.D. too small causing high velocity.

8) Valving too small, causing high velocity.

9) Improper air circulation around reservoir.

10) System relief valve set too high.

11) Power unit operating in direct sunlight or ambient temperature is too high.

Foreign matter sources in circuit
1) Pipe scale not properly removed.
2) Sealing compound (pipe dope, Teflon tape) allowed to get inside fittings.
3) Improperly screened fill pipes and air breathers.
4) Burrs inside piping.
5) Tag ends of packing coming loose.
6) Seal extrusions from pressure higher than compatible with the seal or gasket.
7) Human element... not protecting components while being repaired and open lines left unprotected.
8) Wipers or boots not provided on cylinders or rams where necessary.
9) Repair parts and replacement components not properly protected while stored in repair depot. (Rust and other contaminants).

Troubleshooting Pumps

Pump makes excessive noise
1) Check for vacuum leaks in the suction line. (Such as leak in fitting or damaged suction line.)

2) Check for vacuum leaks in the pump shaft seal if the pump is internally drained. Flooding connections with the fluid being pumped may cause the noise to stop or abate momentarily. This will locate the point of air entry.

3) Check alignment with drive mechanism. Misalignment will cause premature wear and subsequent high noise level in the operation.

4) Check manufacturer's specifications relative to wear possibilities and identification of indications of wear as high operating noise level, etc.

5) Check compatibility of fluid being pumped against manufacturer's recommendations.

6) Relief or unloading valve set too high. Use reliable gauge to check operating pressure. Relief valve may have been set too high with a damaged pressure gauge. Check various unloading devised to see that they are properly controlling the pump delivery.

7) Aeration of fluid in reservoir (return lines above fluid level).

8) Worn or sticking vanes (vane type pump).

9) Worn cam ring (van type pump).

10) Worn or damaged gears and housing (gear pump).

11) Worn or faulty bearing.

12) Reversed rotation.

13) Cartridge installed backwards or improperly.

14) Plugged or restricted suction line or suction strainer.

15) Plugged reservoir filler breather.

Reservoir Filling (Cont.)

Refer to the component manufacturer's catalog for fluid requirements. The cleanliness of the fluid going into the reservoir is very important, and in some cases, even new oil out of the drum is not adequate. We recommend that any fluid being transferred into the reservoir be done with the transfer pump with a 10 micron filler installed.

Start-Up Procedure

1) Open any ball or gate valve (if applicable) located in the pump suction line.

2) Back the system relief valve and/or pump pressure compensator adjustment knob out, so that the pressure will be near zero during the initial start.

Note:
If the Power unit has been provided with a variable displacement pump or any piston pump, the pump case should be filled with clean oil prior to priming. In most cases this can be accomplished by disconnecting the pump case drain line and pouring the oil into the pump case drain port.

3) If the system has been provided with an open center directional valve, the oil during start-up will flow directly back to tank. If the system has a closed center valve, it may be necessary to loosen a fitting momentarily at the pump discharge, to bleed any air in the pump during the priming operation.

4) Jog the pump motor once, and verify that the pump is rotating in the same direction as the arrow tag on the pump case. If the direction is incorrect, reverse two (2) of the three (3) motor leads, and recheck the rotation.

5) Jog the pump/motor (3) to (6) times to prime the pump and allow the pump to run for several minutes at zero pressure. Check the piping for any leaks and correct immediately. (Leaks in fittings and tubing can be the result of vibration during shipping.)

6) Begin adjusting the relief valve and /or pump compensator to increase the pressure gradually. Note: on systems with open center directional valves, it will be necessary to actuate the valve to build pressure.

7) Continue increasing pressure until normal operating pressure is obtained, and recheck system for leaks. Lock adjustment screws in place.

Note
If the system has been provided with a pressure compensator pump and a relief valve, adjust the relief valve approximately 300 PSI higher than the compensator so that excessive heat is not generated by the relief valve.

8) During the start-up sequence, all filters should be monitored closely. Replace any filters element immediately, as soon as they begin to go into by-pass as indicated on the visual indicator.

9) After the entire system has been wetted with fluid, refill the reservoir to the normal operating level.

10) Verify that the cooling water to the heat exchanger (if applicable) is flowing. If the power unit has been provided with a water control valve, and the oil temperature is exceeding 135°F, adjust the valve to increase the water flow.

Special Tools

All normal service and maintenance on standard power units can be accomplished with standard hand tools. No special tools are required.

General Maintenance

Electric Motors – Lubricate as recommended by the motor manufacturer.

Filters – Change or clean as required or as indicated on filters supplied with visual indicators. Make sure to check indicators shortly after start-up.

Suction Strainers – Should be cleaned after 10 hours of operation initially and every 100 hours thereafter.

Reservoirs - Maintain oil level at all times. The oil should be checked after the first 100 hours and verify that the class of oil meets the requirements of the pump being used. Change the oil every 1000 to 2000 hours depending on the application and operation environment.

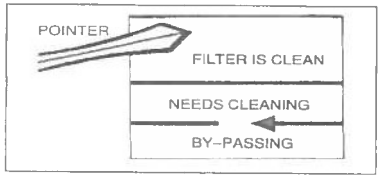
Recommended Spare Parts

Spare filter elements should be purchased with the power unit, and be available during the start-up operation. Other spare parts may be required, and are a function of the duty cycle of the hydraulic system, operation environment, and the acceptable down time of the equipment.

Preventive Maintenance

Filter Service

Filters must be maintained. The key to good filtration is filter maintenance. A machine may be equipped with the best filters available and they may be positioned in the system where they do the most good; but, if the filters aren't serviced and cleaned when dirty, the money spent for the filters and their installation has been wasted. A filter which gets dirty after one day of service and is cleaned 29 days later gives 29 days of non-filtered fluid. A filter can be no better than the maintenance provided.



Maintenance Suggestions

1) Set up a filter maintenance schedule and follow it diligently.
2) Inspect filter elements that have been removed from the system for signs of failure which may indicate that the service interval should be shortened and of impending system problems.
3) Never return to the system any fluid which has leaked out.
4) Always keep the supply of fresh fluid covered tightly.
5) Use clean containers, hoses, and funnels when filling the reservoir. Use a filter cart when adding oil is highly recommended.
6) Use common sense precautions to prevent entry of dirt into components that have been temporarily removed from the circuit.
7) Make sure that all clean-out holes, filter caps, and breather cap filters on the reservoir are properly fastened.
8) Do not run the system unless all normally provided filtration devices are in place.
9) Make certain that the fluid used in the system is of a type recommended by the manufacturers of the system or components.
10) Before changing from one type of fluid to another (e.g., from petroleum base oil to a fire resistant fluid), consult component and filter manufacturers in selection of the fluid and the filters that should be used. Also consult the publication "Recommended Practice for the use of Fire Resistant Fluids for Fluid Power Systems" published by the National Fluid Power Association.
11) MFP offers an oil sampling kit which can be used to ascertain the condition of the system fluid.

Maintaining Proper Oil Temperature

Hot oil in your equipment's hydraulic system is one of the primary causes of poor operation, component failure and downtime. Here are some pointers on maintaining proper oil temperature.

The oil in your hydraulic system was designed for operation within a specified temperature range. You may be able to run it at hotter temperatures for short periods of time, intermittently, without adverse effects. If you run continuously with oil that's too hot, your equipment will operate poorly causing key component failure and machine downtime.

"Hot oil" is a relative term. In most cases, 120°F at the reservoir is considered an ideal operating temperature. Always take an oil temperature reading at the reservoir, not at a component or any of the piping.

Some hydraulic systems are designed to operate at 130°F or higher. If you don't know the maximum operating temperature for your equipment, check your component manual for temperature and viscosity limitations.

How can you keep your equipment's hydraulic system from running too hot?

1) Set up a regular schedule for checking the oil temperature, appearance, smell and feel. Change oil as recommended by the equipment manufacturer.
2) Be prompt about removing, checking and repairing or replacing valves, pumps or other components that are running hot.
3) If relief or flow-control valves are running hot, check and adjust their settings. Follow your equipment owner's manual.
4) Break in new components gradually. New, close fitting parts expand at different rates, and are especially prone to seize when they get too hot.
5) Start a cold pump motor on hot oil by jogging just enough to draw the hot oil into the component. Then wait a few minutes to allow the temperature to equalize in all the pump's parts. Repeat until the temperature on the outside of the pump is the same as that on the piping.
6) Keep your equipment clean. A thick layer of dirt acts as insulation. It will prevent the hydraulic system from getting rid of heat.

Maintenance Suggestions (Cont.)

7) On hot days, and in hot climates, check and change the oil more frequently. Be sure to use an oil recommended for hot weather operation by the equipment manufacturer or oil supplier.

Measuring Oil Temperature

There are several ways to check the temperature of the oil. The best, most accurate method is by means of a thermometer. On some machines, this is mounted on the reservoir. Make it a habit to check the thermometer periodically, after the equipment has been running for more than an hour.

If your machine doesn't have a reservoir thermometer, use the "palm test". First check the tank with your fingertip; if it's not too hot to touch, place your palm on the tank. You'll be able to hold it there without discomfort if the oil temperature is about 130°F or below.

Isolating Trouble-Spots

To determine which components are "running hot" and overheating the oil, feel the outlet fittings and lines at the valves, pumps and motors. If the oil temperature is normal going into a component but hot coming out, that could be one of the potential problem areas.

A sticking valve can cause excessive heat. If a spool does not return promptly to the neutral position, the pump flow will be dumping continuously. This builds up heat rapidly.

If a relief valve is set too low, part of the oil will be dumped across the valve with every cycle. This too, generates excessive heat. Even when all valves are set properly, they may not be operating well because of worn orifices or seals.

Always remove and check the hot components first.

Check Oil Samples Periodically

Checking oil temperature periodically is good preventive maintenance. So too is the practice of periodically siphoning an oil sample from the reservoir, and comparing it with a sample of clean, new oil.

Oil that has been running too hot will look darker and feel thinner than new oil. It will also smell burned. Normally it will contain more contaminants, because hot oil leads to accelerated wear of component parts.

Troubleshooting

Troubleshooting Areas

Dirty Oil
1) Components not properly cleaned after servicing.
2) Inadequate screening in fill pipe.
3) Air breather left off. (No air breather provided or insufficient protection of air breather).
4) Tank not properly sealed.
5) Pipe lines not properly covered while servicing machine.
6) Improper tank baffles not providing settling basin for heavy materials.
7) Filter dirty or ruptured.

Fire resistant fluids
1) Incorrect seals cause binding spools.

2) Paint, varnish or enamel in contact with fluids can cause sludge deposits on filters and around seal areas.

3) Electrolytic action is possible with some metals, usually zinc or cadmium.

4) Improve mixtures can cause heavy sludge formations.

5) High temperatures adversely affect some of the fluids, particularly the water base fluids.

6) Adequate identification of tanks containing these fluids should be provided so that they will be refilled with the proper media.

7) As with mineral base oils, nuisance leaks should be remedied at once.

8) Make certain replacement parts are compatible with fluid media.

Foaming Oil
1) Tank line not returned below fluid level.

2) Broken pipe.

3) Line left out between a bulkhead coupling and the bottom of the tank after cleaning.

4) Inadequate baffles in reservoir.

5) Fluid contaminated with incompatible foreign matter.

6) Suction leak to pump aerating oil.

7) Lack of anti-foaming additives.

Appendix 3

THERMAL OXIDIZER MALFUNCTION/FAILURE REPORT

Permit Condition: PTI MI-ROP-N2915-2017aFG-EG789 VI (5) Monitoring/Record Keeping
RTO Control Equipment for Engine Test Cells FG-EG789

Toyota Motor North America R&D (TMNA)
Evaluation Building: RTO Control Equipment for Engine Test Cells FG-EG789
1555 Woodridge Avenue
Ann Arbor, MI 48105

NAME (PRINT): _____

NAME (SIGNATURE): _____

DATE OF REPORT: _____

DATE AND TIME OF OCCURANCE: _____

DURATION OF THE OCCURANCE: _____

DESCRIPTION OF OCCURANCE:

_____
_____
_____
_____
_____
_____

CORRECTIVE PROCEDURES TAKEN TO CORRECT OCCURANCE:

_____
_____
_____
_____
_____
_____
_____
_____
_____

Appendix 4

PERCEPTIVE RTO ELECTRICAL SPARE PARTS

Catalog Number	Description
2711-PT15C22D9P	15 PANELVIEW+7 HMI
6642VLT/45-15MLJ Group MRP4102	BURNER MANAGEMENT SYSTEM
783-3C-24D	24VDC THREE POLE RELAY
782-2C-24D	24VDC TWO POLE RELAY
781-1C-24D	24VDC SINGLE POLE RELAY
783-3C-120A	120VAC THREE POLE RELAY
FAZ-D10-1-NA-SP	1 POLE 10 AMP BREAKER -24VDC
FAZ-D5-1-NA-SP	1 POLE 5 AMP BREAKER-24VDC
FAZ-D3-1-NA-SP	1 POLE 3 AMP BREAKER-24VDC
OR1500LCDRTXL2U	Smart App LCD UPS 1500VA 1125W
1769-L33ERM	Controller
1769-CJC	COLD JUNCTION KIT
1769-PA4	DIGITAL INPUT MODULE
1769-IQ16	DIGITAL INPUT MODULE
1769-OB16	DIGITAL OUTPUT MODULE
1769-IF8	ANALOG INPUT MODULE
1769-IT6	T/C MILLIVOLTV MODULE
1769-OF4	ANALOG OUTPUT MODULE
1769-OF8C	ANALOG OUTPUT MODULE
1769-OF8V	ANALOG OUTPUT MODULE
1769-IR6	RTD INPUT MODULE
SE2-SW10UG-2P-T	8 PORT ETHERNET SWITCH /2 SFP
PSP24-240S	24VDC POWER SUPPLY
700S-DCP710Z24	MASTER CONTROL RELAY
3118203	CIRCUIT BREAKER TERMINAL BLOCK
712194	1 AMP CIRCUIT BREAKER
712152	1/2 AMP CIRCUIT BREAKER

PERCEPTIVE RTO ELECTRICAL SPARE PARTS

FAZ-D10-3-NA	3 POLE 10 AMP BREAKER
FAZ-D20-3-NA	3 POLE 20 AMP BREAKER
100-C23EJ10	CONTACTOR
100-A20	AUXILLARY CONTACT
193-ED1EB	OVERLOAD RELAY
BW400SAGU-3P400SB	400 AMP MAIN BREAKER
BW250JAGU-3P200SB	200 AMP BREAKER
CIMR-PU4A0139FAA	100 HP VFD
SI-EN3	ETHERNET MODULE
FDC-L41-511001	HIGH TEMPERATURE LIMIT
M22-WLKV-W-K10-W	ILLUMINATED SELECTOR SWITCH
M22-LED-W	WHITE PILOT LIGHT
M22-LED-G	GREEN PILOT LIGHT
M22-DDL-GR-X1-X0-G	DOUBLE PUSH BUTTON
M22-DDL-GR-X1-X0-K11-B	DOUBLE PUSH BUTTON
M22-D-S-K10	PUSH BUTTON
1734-AENTR	POINT I/O ETHERNET ADAPTER
1734-IB8	8 POINT DIGITAL INPUT
1734-OW4	DIGITAL OUTPUT
1734-IT2I	THERMOCOUPLER INPUT
1734-TBS	I/O CARRIER
1734-TBCJC	T.C. I/O CARRIER
PSP24-060S	24VDC POWER SUPPLY
FAZ-D5-1-NA-SP	1 POLE 5 AMP BREAKER- 24VDC
FAZ-D3-1-NA-SP	1 POLE 3 AMP BREAKER
CHART RECORDER	
TVMUGR-888800-440-22-5-030-R0020G-000	HONEYWELL 32 POINT MULTITREND
460ETCMC-N34-D	RTA MODBUS MASTER

PERCEPTIVE RTO MECHANICAL SPARE PARTS

Conti Corp. Recommended RTO Spare parts			
Discription	QTY	Price	Total
Endustra/TriVent combustion air Filter	1	$614.00	$614.00
Dwyer Magnehelic gauge 0-10" 605-10	1	$294.00	$294.00
MLM-S ceramic media 12"x12"x4"	100	$58.00	$5,800.00
UV Scanner	1	$580.00	$580.00
Supply Fan pressure switch .6-1.6"	2	$274.00	$548.00
NYB Pressure Blower Size 10906A05	1	$3,247.00	$3,247.00
Supply Fan damper actuator, Type AR modulating package. MAR-10-30-4	1	$4,860.00	$4,860.00
Ignition transformer 120 / 6000v	1	$140.00	$140.00
Type K thermocouple 12" 4-12K1U16-D	2	$90.00	$180.00
Type K thermocouple 30" 4-30K1U16-D	2	$102.00	$204.00
Parker rotary actuator LTR202-090P-AA11-C	1	$2,434.00	$2,434.00
Parker cylinder 1H000182694	1	$1,865.00	$1,865.00
GP:50 Low pressure transducer 310-D-SZ-2-AA	1	$1,967.00	$1,967.00
Prices good for 30 days			
Freight costs excluded			