KARN FACILITY
DE Karn 3 and 4 Plant

MAINTENANCE AND MALFUNCTION ABATEMENT PLAN
Units 3 & 4

April 2019

I. INTRODUCTION

A. SCOPE

This Maintenance and Malfunction Abatement Plan (MMAP) covers the monitoring, maintenance and operational requirements associated with the Karn 3 & 4 boilers. This MMAP will assist in preventing, detecting and correcting malfunctions or equipment failures which could result in emissions exceeding applicable limitations.

B. PURPOSE

This plan has been developed to address the Michigan Department of Environmental Quality – Air Quality Division (AQD) Air Pollution Control (APC) Part 9 requirements, Emissions Limitations and Prohibitions-Miscellaneous, and the Karn Renewable Operating Permit (No. MI-ROP-B2840-2014c) for FG-KARN34, Special Condition IX.2, which states that, "The permittee shall maintain a written preventative Malfunction Abatement Plan (MAP) that meets the requirements specified in Rule 911(2). The actions taken to correct and prevent a reoccurrence of a malfunction shall become part of the preventative MAP."

A MAP 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.

II. SOURCE DESCRIPTION

Karn Boilers #3 and #4 are 7290 and 8030 million BTU per hour natural gas and oil fired boilers (i.e., dual fuel), respectively, with low Nitrogen Oxide (NOx) burner technology.

Both Karn 3 & 4 units are designed specifically to provide peaking electric power to the system quickly when system demands dictate. These units are required to start up with

little or no advanced notice and supply power at varying loads until such time as they are no longer required, then they are quickly shutdown. Each unit is capable of generating 638 million watts of power.

Each boiler has two forced draft fans which draw outside air and discharge it through steam/air heaters to the boiler burners for combustion. Each boiler also has two induced draft fans which draw the hot gases out of the boiler and exhaust to a single plant stack.

Karn 3 & 4 boilers have been modified to enable them to burn natural gas as well as oil, separately or in any combination. The old 30 oil burner assemblies were replaced with 30 gas ignitors and 30 low NO_X oil/gas combination burners. These new burners have primary and secondary air shrouds, atomizing steam and diffusers for the oil guns and flame detection monitors.

There are also two auxiliary boilers west of the plant (auxiliary boilers A & B), which are used to supply plant heating steam when the units are shut down and startup process steam when the units are starting up. Each of these auxiliary boilers has one natural gas ignitor and one natural gas low NO_X burner with a turn down ratio of 10 to 1. These boilers are rated at 225,000 lbs/hr, with normal operation superheat outlet pressure of 250 psig (safety valve setting of 265 psig) and temperature of 525 ºF. Auxiliary boilers A & B exhaust via the same common plant stack as Karn Units 3 and 4.

FUEL SUPPLY SYSTEMS

The oil storage tank farm, located southeast of the Karn Plant, has one operational 225,000 barrel storage tank (i.e., Tank A). Oil from Tank A can be transferred to either of two 20,000 barrel day tanks. The oil from either of these day tanks, located near the plant, may be burned in either the Karn 3 or 4 boilers.

The oil from the day tanks is pumped to the proper boilers using separate burner oil pumps. Each boiler oil supply system has a steam heating skid which allows heating the oil to the proper temperature to improve combustion.

Natural gas for Karn 3 & 4 boilers and both auxiliary boilers may be supplied from either the Consumers Energy gas distribution system or the Saginaw Bay gas transmission system through separate gas regulator stations located south of the plant.

COMBUSTION PROCESS AND EMISSIONS CONTROL

Combustion is the rapid chemical combination of oxygen with fuel which produces heat. When air is supplied to the furnace, the oxygen separates from the nitrogen and joins with the carbon, hydrogen and sulfur elements of the fuel. Three factors affect the efficiency of this combustion cycle: time, temperature and turbulence. The time the fuel takes to burn is affected by the size of the fuel particles and the combustibility of the fuel. Temperature provides the condition necessary to begin and sustain the burning process. Turbulence promotes adequate mixing of the fuel and air to burn the fuel completely.

When a boiler is first fired, it is relatively cold and complete combustion of the fuel is difficult. To improve this condition the outside ambient air is preheated by passing it through large steam radiators before it is blown into the furnace as combustion air. The oil is also preheated to raise its combustibility factor. When the pressurized oil enters the furnace through the burner guns, it is mixed with atomizing steam which breaks the oil droplets into a fine mist, which increases the combustibility of the oil and decreases the burn time. Fuel pressure is controlled to provide the proper amount of fuel in relation to the amount of air in the furnace. Burner air shrouds control the distribution of air to each individual burner and air diffusers at the burner tips introduce the proper amount of air/fuel

turbulence for complete combustion. Airflow amount and balance across the furnace is controlled by the forced draft fans and dampers. This is critical so that oxygen levels are adequate in all areas of the boiler and there is always more air (excess air) than is needed for combustion to ensure that all the fuel is being burned completely. Natural gas can also be burned which follows the same combustion process minus the need for atomizing steam.

Only when all the aforementioned factors affecting combustion are controlled properly, will complete and clean combustion occur.

NO_x CONTROL

When burner flames are short, bright, hot and turbulent, combustion is complete and unburned particulate matter is low. This condition has a negative effect in that it causes high levels of NO_x to be generated. To lower the NO_x, yet keep the particulate matter at a reasonable level, Karn 3 & 4 boilers were retrofitted with Riley STS® (Swirl Tertiary Staged) low NO_x burners when they both were converted to burn natural gas. These burners incorporate improved combustion designs which better control the air/fuel ratio and turbulence to produce a slower, lazier flame which generates less NO_x, but still fully combusts the fuel. Special oil burner tips were also designed and installed to attain a combustion condition that was satisfactory for both opacity and NO_x.

SO_2 CONTROL

When medium sulfur oil (MSO) with sulfur contents above the 1% limit is burned in either Karn 3 or 4 boilers, it is blended in the boiler with natural gas to control the SO_2 output below the monthly limit. SO_2 control is accomplished through a combination of fuel supply, fuel sampling and boiler firing controls. When burning MSO, it is sampled regularly to determine the actual sulfur content.

III. REGULATORY ANALYSIS

Karn Unit Nos. 3 and 4 each have the following emission limitations:

- NOx emission rate of 0.45 lb/MMBtu based on a daily average.
- SO2 emission rate of 1.11 lbs/MMBtu based on a monthly calendar average of those hours when Karn 3 and/or Karn 4 are in operation.
- PM emission rate of 0.10 lbs/1000 pounds of exhaust gases, corrected to 50% excess air
- 20% opacity per 6-minute average, except for one (1) 6-minute average per hour of not more than 27% opacity.

Emissions are monitored in the common stack via Continuous Emissions Monitoring Systems (CEMS) for NO_x and SO_2 and a Continuous Opacity Monitoring System (COMS) for opacity monitoring.

IV. OPERATION OF THE UNITS, including START-UP and SHUT-DOWN

The Units shall be placed in service and removed from service in accordance with Plant Standard Operating Procedures (SOPs), Emergency Response Procedures (ERPs) and Alarm Response Procedures (ARPs) utilizing good air pollution control practices for minimizing emissions.

1. Oil burner steam purging

   Conducted during light-off and shutdown operations to keep the burners clean and reliable. This involves blowing steam through the burner and into the furnace each

time a burner is shut down, to remove any oil that may be laying in it. This keeps the oil from being baked inside the burner causing it to plug and require maintenance. This purging may cause a certain amount of smoke because of poor combustion.

2. Cold Start-ups

During cold boiler start-up conditions, boiler firing temperature restrictions allow only minimal firing until the boiler has gained a certain amount of temperature. This can cause poor combustion conditions until the boiler heats up and the firing rate can be increased to create proper combustion, thus the Units start-up on natural gas fuel only.

3. Operational upsets

Operators continually monitor the boiler operations and make adjustments to air and/or fuel ratios to optimize operational conditions and minimize emissions. Operators take actions to prevent high NOx, SO_2 and opacity alarms as well as timely address all alarms received. If an alarm cannot be cleared, the Production Supervisor is notified promptly.

4. Rapid Load changes

When loading and unloading the unit quickly, oil burners must be started and stopped often which may contribute to opacity spikes during the startup/shutdown cycles. Operators will adjust the loading / unloading rate to minimize opacity exceedances.

V. MONITORING PARAMETERS

The operation is controlled and monitored from a central Distributed Control System (DCS). Online analyzers and alarms are an integral part of the system instrumentation. They warn Operators of impending problem situations. In all cases, alarms will be investigated and responded to accordingly. The following parameters are monitored by plant personnel.

A. NOx & SO_2 Emissions

NOx & SO_2 emissions are monitored for potential exceedances of emission limits. Alarms are set-up in the CEMS Operator Interface Panel to generate audible and visual alarms to the Operators to an exceedance of the limit such that corrective actions may be taken.

B. Operational Parameters

Operators monitor airflow vs fuel flow, and oxygen and fuel pressures/temperatures because these parameters directly affect emissions. Specific operating parameters are listed below.

Monitored Parameter	Acceptable Range	Alarm Setpoint
Opacity, 1-min. & 6-min.	0-20%	20.5%
Oxygen	1-10.5%	Load Dependent
Airflow	18-100%	Load Dependent
Fuel flow	0-100%	Load Dependent
Oil Pressure	120-260 psig	<65 or >295 psig
Gas Pressure	2-37 psig	<1.5 or >35 psig
Oil Temperature	140-220°F	265°F

Operators respond to alarms in accordance with the Plant Alarm Response Procedures. Examples of corrective actions are summarized in the Malfunction Abatement section below.

VI. MALFUNCTION ABATEMENT

During otherwise normal operation, an operator may experience some abnormal conditions that will result in high opacity or NOx rates and require immediate attention. Prompt response to alarms or abnormal conditions will reduce the risk of emission noncompliance and equipment damage. The operation will be restored to normal as quickly as possible in response to any noted abnormal condition.

A. POTENTIAL MALFUNCTIONS

The following section identifies representative alarms of abnormal process conditions or operating problems, possible causes, and corrective actions to recover from the condition.

1. **High NOx Alarms / Emissions**

CAUSE	CORRECTIVE ACTION(S)
Flame temperatures too high	Adjust combustion parameters
NOx analyzer malfunctioning	Inspect, calibrate and replace as necessary

2. **High SO_2 Alarms / Emissions**

CAUSE	CORRECTIVE ACTION(S)
Fuel oil sulfur content too high	Increase the firing of natural gas; Lower the MSO firing rate
SO_2 analyzer malfunctioning	Inspect, calibrate and replace as necessary

3. **High Opacity 6-minute Average**

CAUSE	CORRECTIVE ACTION(S)
Fuel temp too low	Increase gradually
Burner malfunction	Troubleshoot to resolve proper burner function; Remove improperly functioning burner
Air imbalances	Adjust excess air levels and balancing air distribution
Unknown or Additional Corrective actions	Reduce load from Unit / Remove Unit from service

4. **Loss of Gas Supply / Pressure**

CAUSE	CORRECTIVE ACTION(S)
Sudden loss of gas pressure	Reduce load from Unit / Remove Unit from service

VII. PREVENTATIVE AND PREDICTIVE MAINTENANCE

Boiler tuning for combustion optimization in accordance with the MATS regulation (40 CFR Part 63, Subpart UUUUU) will be conducted at least every 36 months, or within 30-days of startup if the Unit is not operating at the time the tune-up is due.

The following general categories of equipment affect emissions and/or opacity and shall be inspected at regularly identified intervals:

- boiler fuel equipment
- burner oil pump equipment
- oil heating equipment
- burner and burner deck equipment
- combustion control equipment
- burner management equipment
- boiler airflow equipment
- combustion air heater equipment
- boiler oxygen equipment
- boiler ID and FD fan equipment
- boiler furnace pressure equipment
- boiler gas control equipment

All equipment inspections shall be documented.

A. RESPONSIBLE PERSON(S) FOR PREVENTATIVE/PREDICTIVE MAINTENANCE

1. The System Engineer has designated responsibilities for determining and establishing predefined Maintenance Plans. As necessary, Maintenance Plans will be updated to include preventative/predictive maintenance and best practices resulting from malfunctions experienced.

2. The Maintenance Lead for the respective equipment will ensure that the activities defined in the Maintenance Plans are carried out and documented on the schedule identified (based on frequency, interval, manufacturer / engineering recommendations, etc.) during scheduled outages of adequate length.

   In addition to the inspections identified above, the Maintenance Plans will include at a minimum the following inspections, which will be conducted during scheduled periodic outages of adequate length. The inspection results and maintenance activities/corrective actions will be documented appropriately.

   Scheduled Periodic Outage Inspections:

   a. Check for signs of corrosion, moisture or in-leakage to the associated ductwork.

   b. Inspect associated man way doors / gaskets, dampers and expansion joints. Repair / replace as necessary.

B. CRITICAL SPARE PARTS

The System Engineer will identify the necessary spare parts to be maintained in stock for quick replacement.

VIII. RECORD KEEPING

A. MAINTENANCE

1. All maintenance activities (including preventative/predictive maintenance and maintenance related to malfunctions) related to the Karn 3 and 4 Plant will be documented electronically and maintained for a period of not less than five years. If some activities occur at frequencies of greater than five year intervals, the history will be extended for those activities such that as a minimum the last maintenance activity performed is retained.

2. All appropriate vendor information, as well as operations and maintenance (O&M) manuals, shall be maintained for reference and training. These documents will also be referenced for supply parts and proper maintenance practices. This information shall be maintained for the life of the equipment.

3. Malfunctions that caused an opacity exceedance are subject to Consent Decree/ROP compliance reporting. Corrective actions shall be documented in the appropriate log and shall be included in the semi-annual reports.

B. OPERATIONS

1. Responses to critical alarms and corrective actions will be documented in electronic logs. Additionally Operators should log the date and time of event and corrective action, applicable notifications / work orders.