INTERNAL COMBUSTION ENGINES

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1.0 SCOPE

This data sheet applies to the inspection and maintenance of gaseous- or liquid fueled reciprocating internal combustion engines (ICEs) greater or equal to 500 hp (373 kW). While guidance is provided for size-sensitive recommendations, it is not possible to address all engine installations. Therefore, engineering judgment is to be used in the application of the recommendations for smaller engines under 500 hp (373 kW).

This data sheet deals only with internal combustion engines and integral engine-compressor units. Separately driven equipment (generators, pumps, compressors, etc.) are beyond the scope of this document.

Recommendations contained in this data sheet are not applicable to engines used to drive fire pumps or emergency electric power generators. Recommendations for these engines can be found in Data Sheet 3-7, *Fire Protection Pumps*, and Data Sheet 5-23, *Emergency and Standby Power Systems*, respectively.

For integral engine-compressor units, additional guidance for fire and explosion perils can be found in Data Sheet 7-95, *Compressors*.

Reference to other data sheets may be necessary to ensure appropriate loss control measures have been taken. Such data sheets include the following:

Data Sheet 9-0/17-0, *Maintenance*
Data Sheet 9-18/17-18, *Prevention of Freeze-ups*
Data Sheet 17-1, *Nondestructive Examination*
Data Sheet 13-18, *Industrial Clutches and Clutch Couplings*
Data Sheet 13-7, *Gears*

1.1 Changes

January 2011. This data sheet has been revised to reflect current technology and best practices. Changes include the following:

- Added information on additional monitoring devices.
- Added new recommendations for engine operation and maintenance.
- Modified information on crankshaft explosions.
- Added recommendations regarding fuel and oil analysis.
- Modified guidance related to engine overhaul, repair, and dismantle activity.
- Updated guidance on contingency planning and spare equipment.
- Added terms to Appendix A, Glossary of Terms.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

All recommendations made in this data sheet pertaining to maintenance of reciprocating components and cylinders of internal combustion engines apply to integral compressors as well (for example, clearance checks of bearings and crossheads, NDE of connecting rods).

2.2 Equipment and Processes

2.2.1 General

Check and prepare all engines as descibed below prior to operation.

2.2.1.1 Ensure wiring and tubing are adequately protected from the heat and vibrations emitted by reciprocating machinery. Use harnesses as specified by the original equipment manufacturer (OEM) to protect wire and tubing bundles from mechanical wear and thermal degradation.

2.2.1.2 Route harnesses to prevent accidental damage from personnel. Place harnesses 6 to 12 inches from connectors to prevent excessive stress or deflection. Support wires and tube bundles so that engine mechanical vibration does not cause excitation of bundles. Resonant frequencies or mechanical wear can result in wire and tubing failure within a short period of time.

2.2.1.3 Ensure new and overhauled units are given a break-in period during which the engine is operated at reduced load. Refer to the OEM's guidelines for specific instructions.

2.2.1.4 Pre-heat and circulate lubricating oil through the bearings prior to unit startup to prevent excessive wear. Arrange the pre-lube pumps to start automatically prior to rolling the engine over for blow-down or starting the engine. In addition, design pre-lube pumps to start automatically when the engine is being shut down. This applies to large medium-speed or slow-speed engines that may only have engine-driven lube-oil pumps.

Provide a lube-oil pressure permissive for engines with electrically driven lube-oil pumps so the engines cannot be rolled over until the lube-oil pressure permissive is satisfied. Do not rotate large engine crankshafts at any speed without pressure lubrication to the bearings.

2.2.1.5 Install mechanical crankcase ventilation on large engines. Decreasing differential pressure (increased crankcase pressure) can be caused by worn, stuck, or broken piston rings, worn cylinder liners, or loss of mechanical ventilation.

2.2.2 Protective Devices

2.2.2.1 Equip all IC engines with protective devices listed in Table 1. Provide separate alarm and trip settings as indicated in the table. Do not use time delays for ICE protective service.

Use protective devices that either shut down the engine or prevent startup if there is a failure (electric or pneumatic) in the shutdown circuitry (i.e., all protective devices will "fail-safe").

Table 1. Protective Devices for Internal Combustion Engines

Device	*Alarm*	*Trip*
High cooling water jacket temperature	X	X
Low engine lube-oil pressure	X	X
High lube-oil temperature	X	X
High bearing temperature (apply only to main bearing thermocouple embedded in the bearings)	X	X
Power cylinder lubrication, no flow[1]		X
Excess engine vibration		X
Engine overspeed detection system[2]		X
Turbocharger: — Thrust bearing failure detector — Low oil pressure Overspeed trip actuator[3] — High lube oil temperature	X X X	X X X X
"Engine running" indicator (for all emergency engines that start automatically)	X	
Auxiliary oil pump running	X	
Crankcase overpressure[4]		X

1. Power Cylinder lube oil no-flow most likely will apply only to slow speed engines with a cross head arrangement.

2. Overspeed shutdown devices are the type that operates totally independent of other engine control functions to protect against runaway and subsequent damages.

3. If recommended by engine manufacturer.

4. Can be caused by overpressure from compressor rod seal leaks on integral engine-compressor units, cracked or worn power piston rings, cracked engine block, and crankcase explosion.

2.2.2.2 Equip all diesel engines of more than 1000 hp (745 kW) with both inlet air and fuel shutoff valves to prevent engines from continuing to run when volatile fumes are present following a unit trip. Spark ignition engines need only be equipped with a fuel shut-off valve.

2.2.2.3 Transmit all actual control instrumentation values and protective device signals for unattended operating engines to monitors at constantly attended location.

2.2.2.4 Provide adequate FM approved crankcase explosion vents. Small engines typically do not have explosion vents.