Practical application of ISO 14224 methods in corporate software

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ISO 14224 Overview

ISO 14224 Petroleum, petrochemical and natural gas industries — Collection and exchange of reliability and maintenance data for equipment

Provides a comprehensive basis for the collection of equipment reliability and maintenance (RM) data in a standard format

Developed by the Offshore Reliability Database (OREDA) JIP

- OREDA Established 1981, data collection 1983-present
- OREDA widely considered to be the most successful initiative of its type
- OREDA authored the first version of ISO 14224 in 1999 and remains closely involved in development of successive versions

Business Case for ISO 14224

Enables data-driven decision-making with high-quality equipment reliability data

Enables corporate line-of-sight between equipment failure events and the bottom line

Helps companies identify where to focus equipment reliability efforts

Data Quality

We need “data collection principles and associated terms and definitions that constitute a “reliability language” …for communicating operational experience.”

Attributes of high-quality RM data

- Standard
- Complete
- Coherent
- Structured
- Aggregated at equipment unit
- Accessible

RM Data Quality Management

Quality Assurance

- Technical hierarchy incorporates ISO 14224 equipment taxonomy
- Malfunction reporting incorporates ISO 14224 normative specifications and notations
- CMMIS validations ensure ISO 14224 data compliance

Quality control

- Event record reviews
- Results-based feedback/training to field personnel

Corporate Metrics
A Bottom-Line Approach

IDENTIFY

- Equipment failure events with the greatest consequences
- Equipment causing those events (bad-actor equipment)

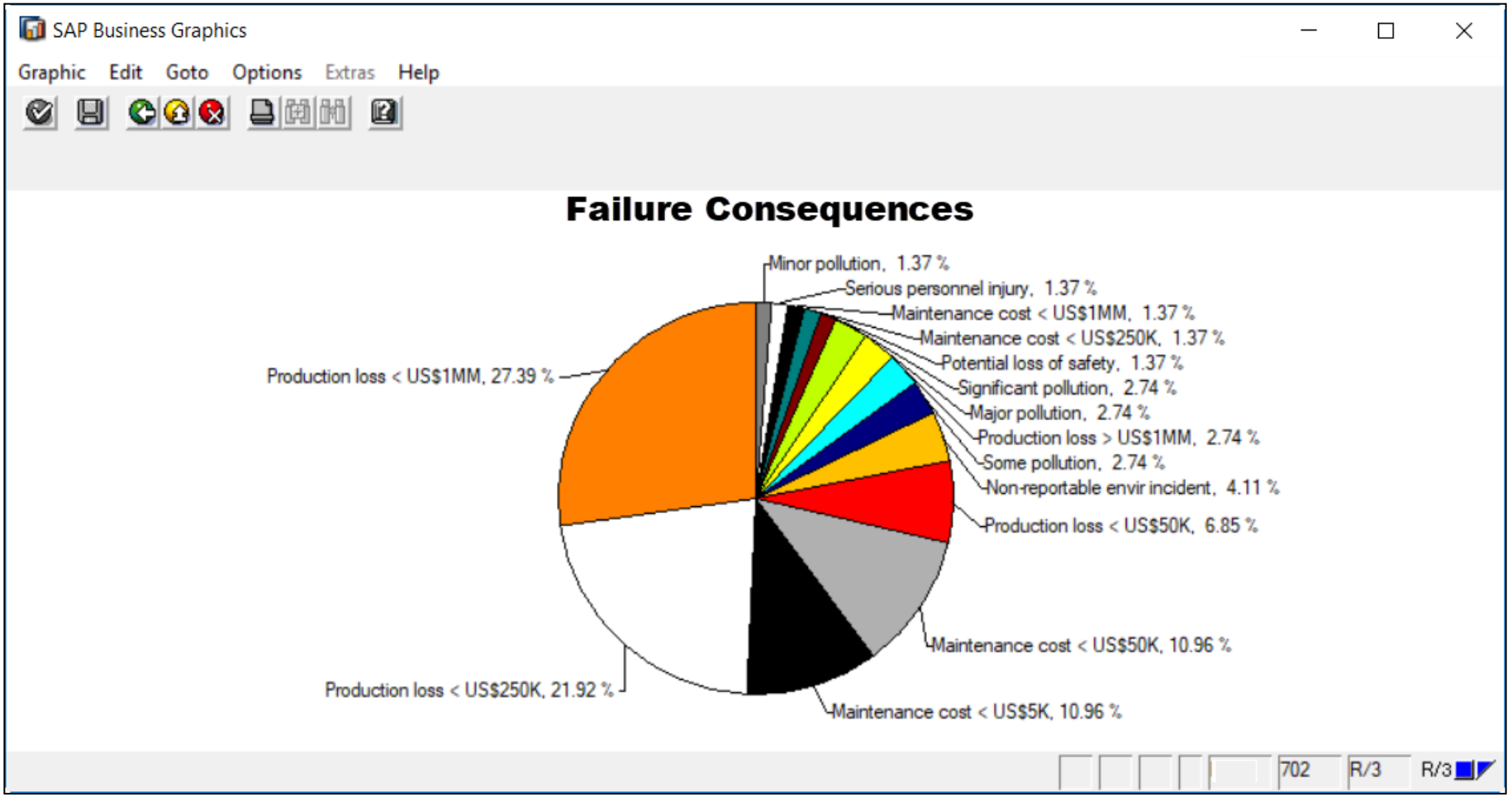
ANALYZE

- High-consequence failure events
- Failure patterns of bad-actor equipment causing them
- Obtain details necessary to take corrective action

RESOLVE

- Bad actor equipment reliability issues
- Implement and prioritize corrective measures

IDENTIFY High-Consequence Failure Events
Corporate Metrics



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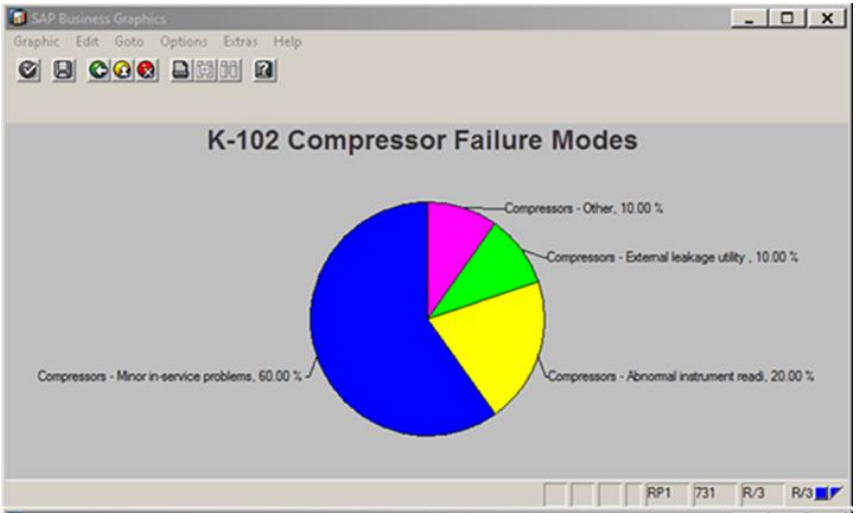
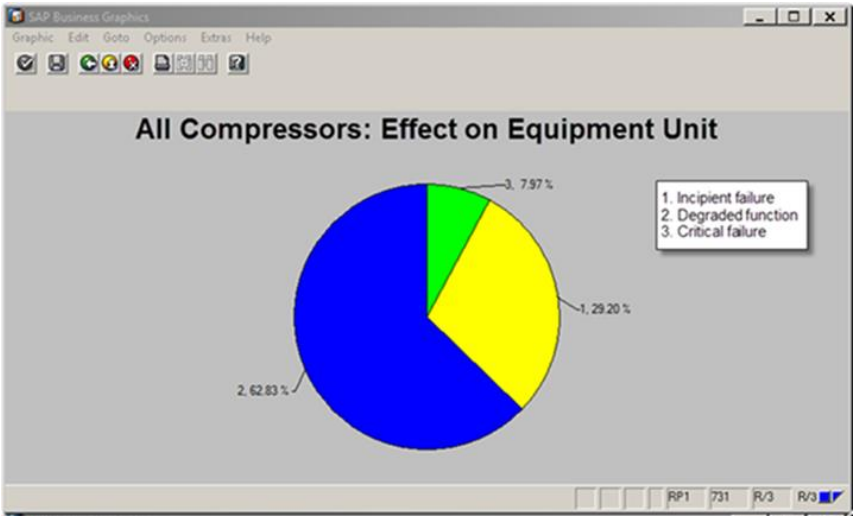
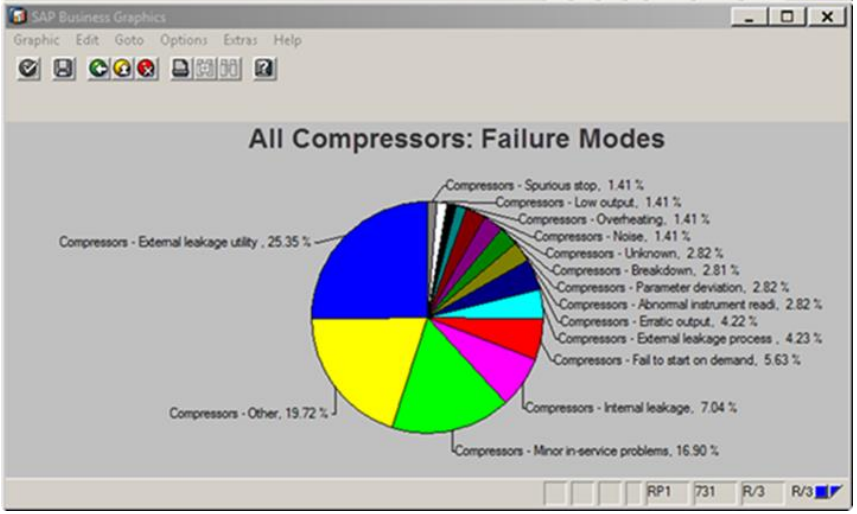
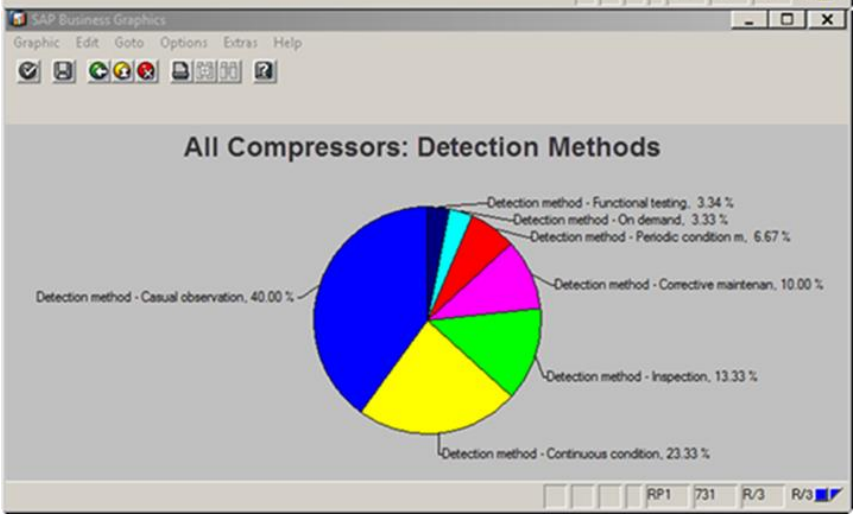
ANALYZE Failure details
Equipment-Level Analysis









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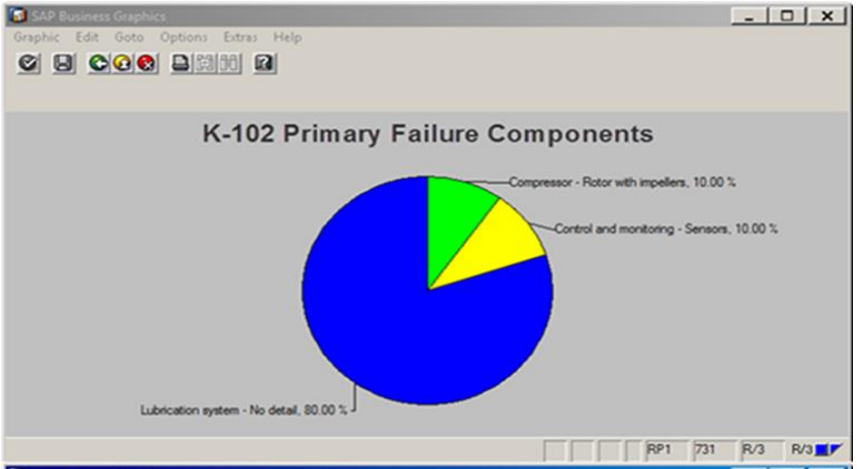
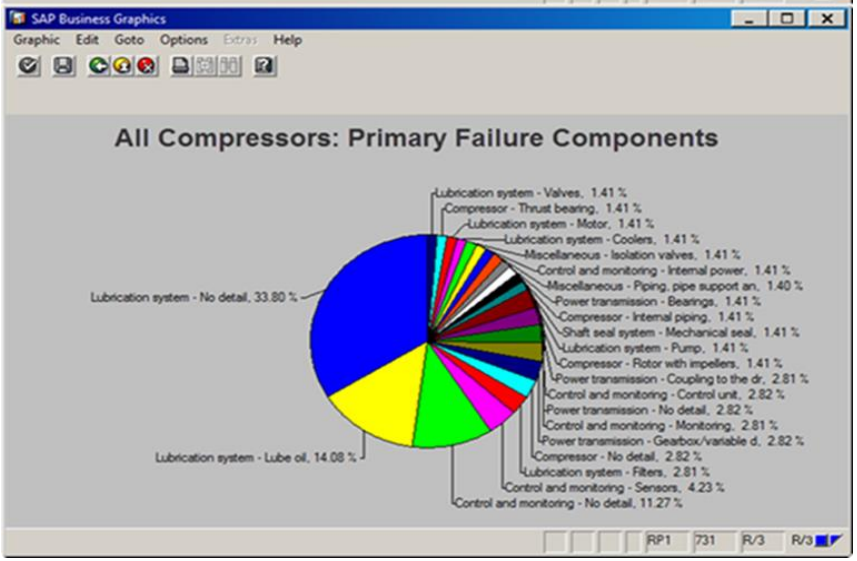
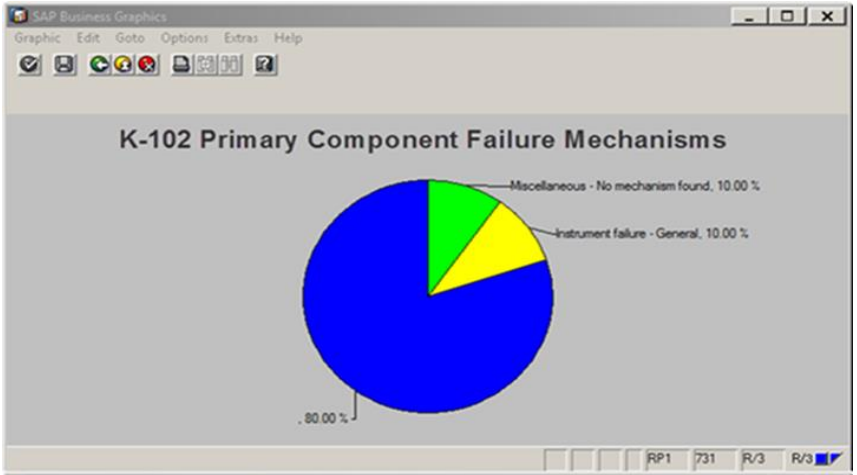
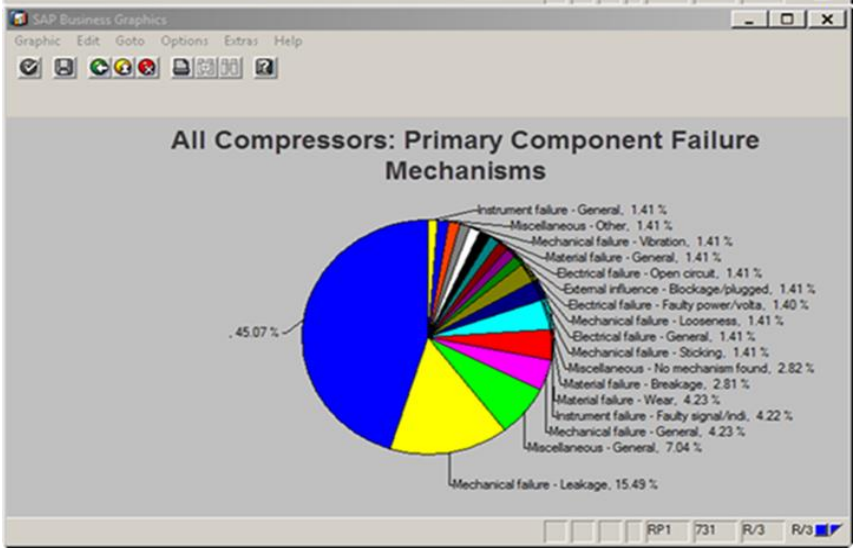
ANALYZE Failure details
Component-Level Analysis









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RESOLVE Bad-Actor Equipment Issues

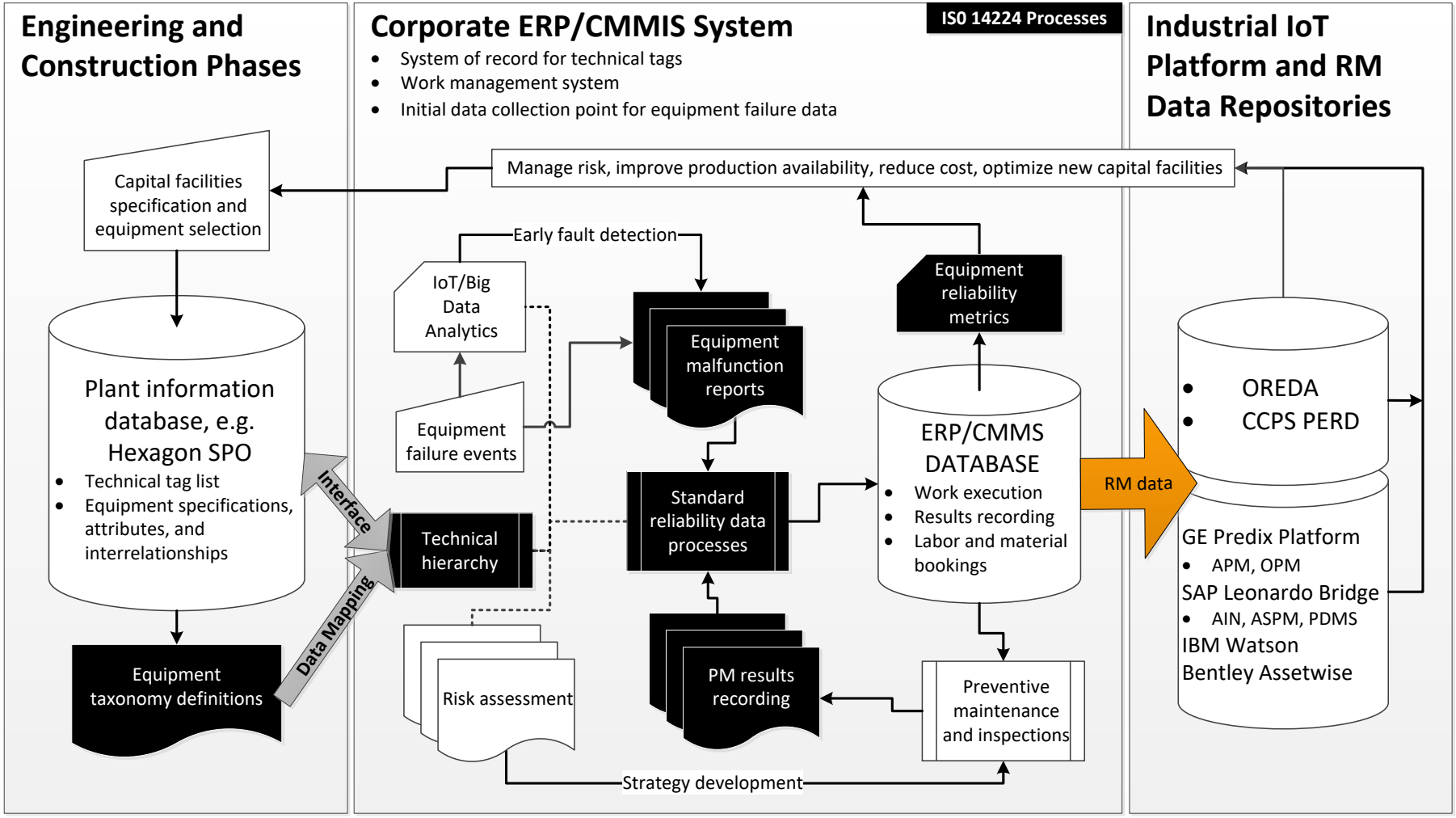
Implement corrective measures for bad actor equipment, e.g.:

- Preventive maintenance
- Inspections
- Procedures
- Facilities changes

Prioritize corrective measures based on:

- Actual consequences
- Future consequence potential

ISO 14224 Solution Landscape



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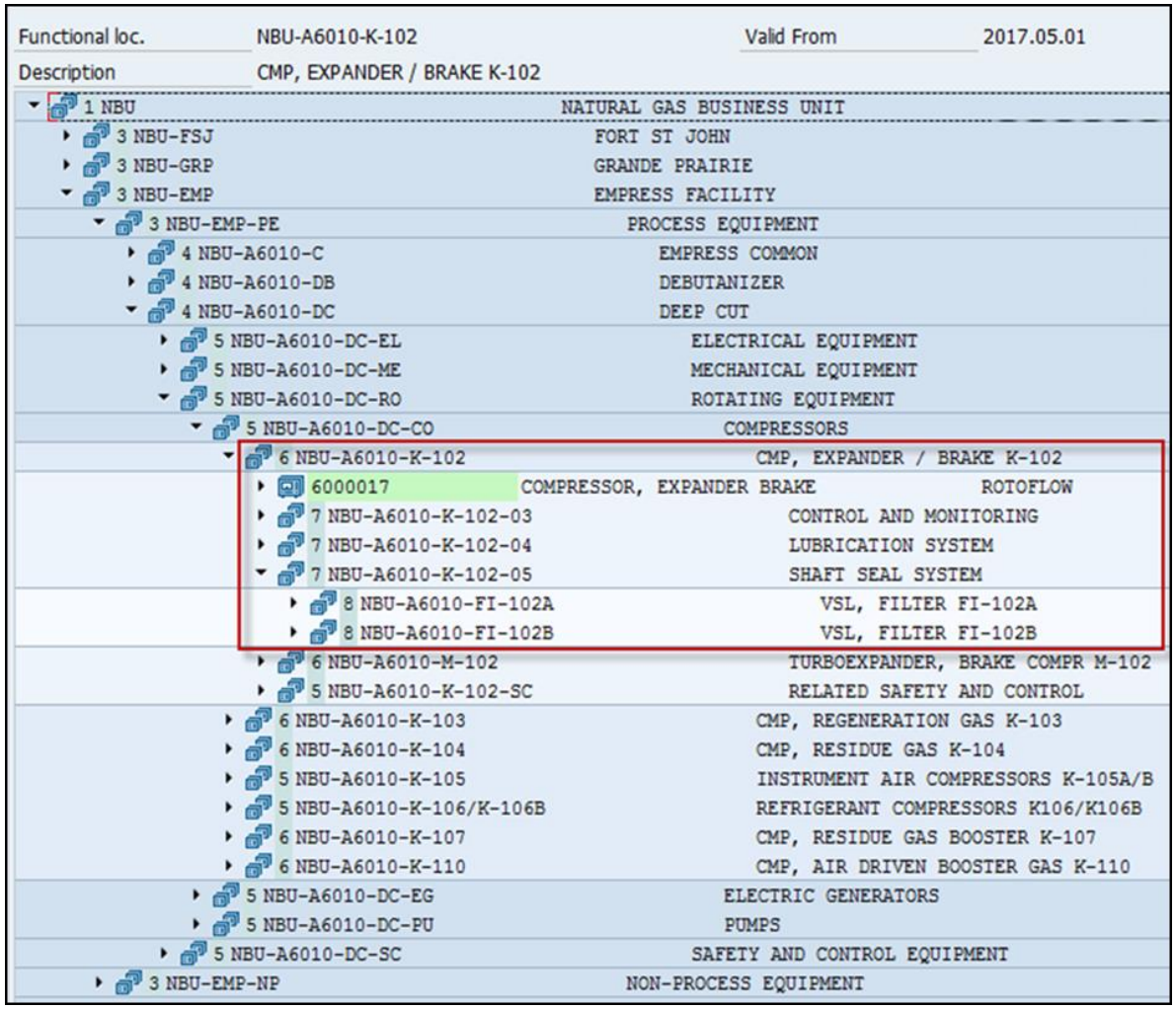
Technical Hierarchy Overview



Asset register

Equipment boundary envelope

Interrelated equipment

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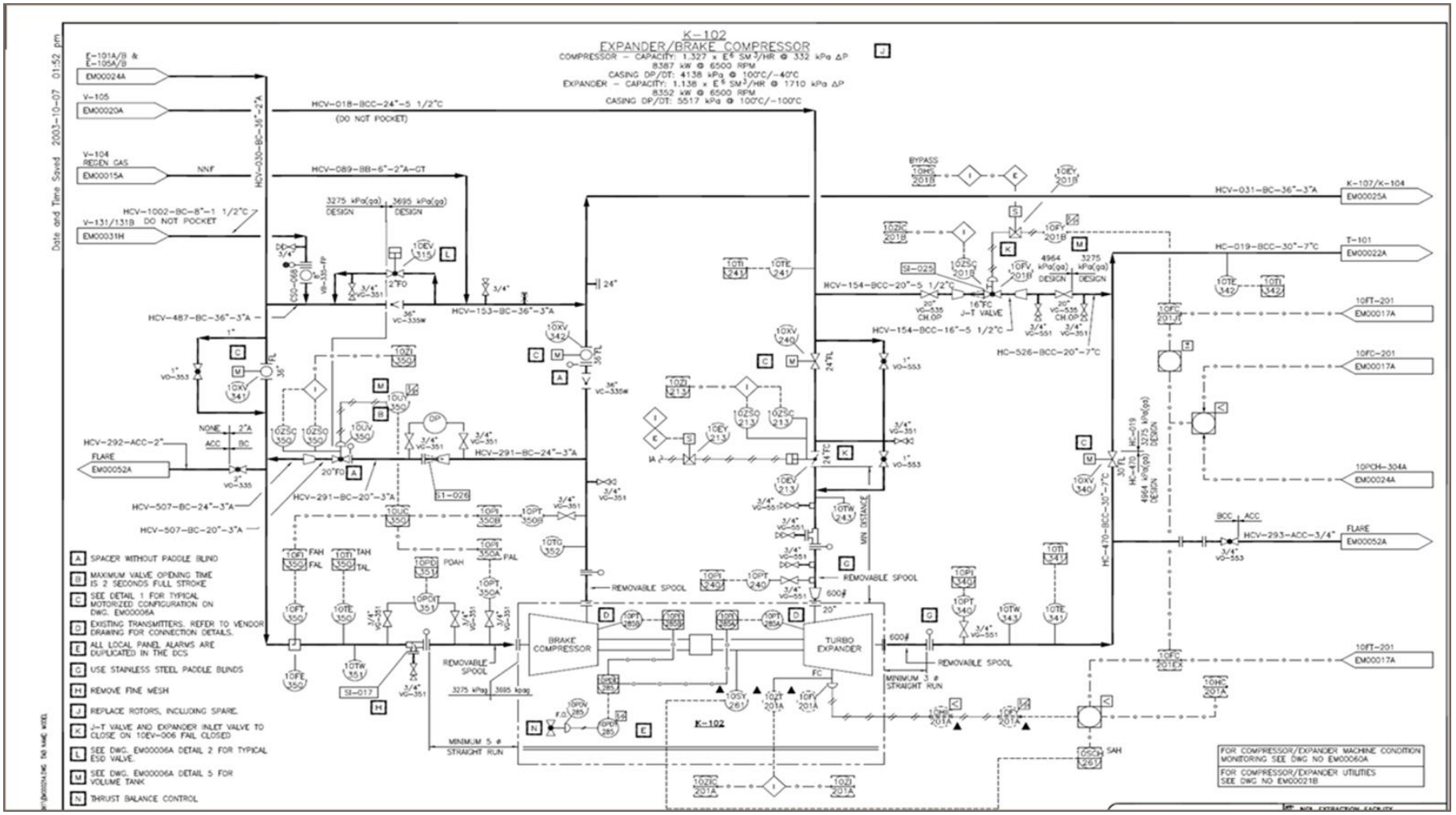
Construction of Technical Structure
Compressor Technical Drawings



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ISO 14224 Boundary Definition

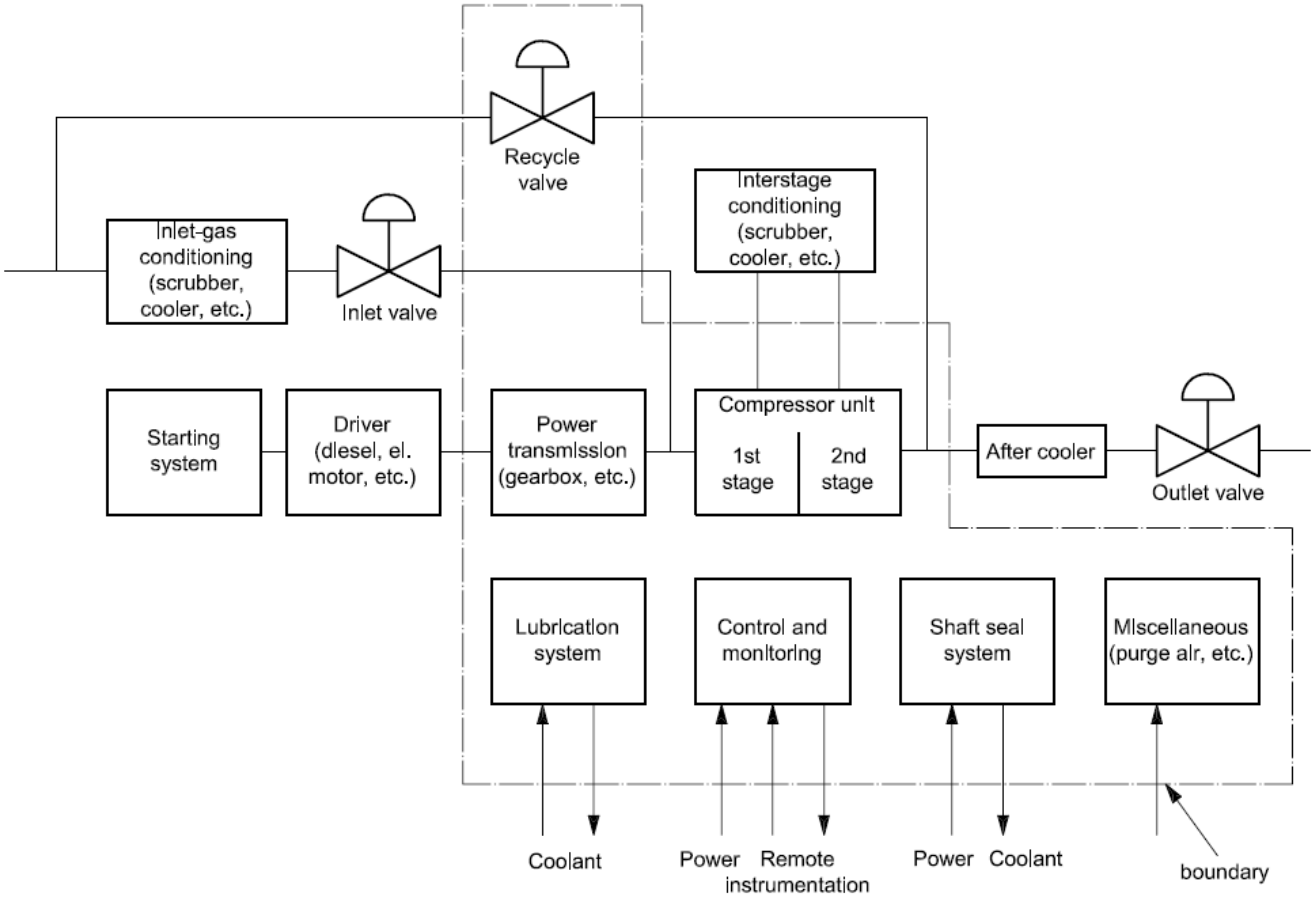

Figure A.2 — Boundary definition — Compressors

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ISO 14224 Equipment Subdivision

Table A.9 — Equipment subdivision — Compressors

Equipment class	Compressors					
Subunit	**Power transmission**	**Compressor**	**Control and monitoring**	**Lubrication system**	**Shaft seal system**	**Miscellaneous**
Maintainable item/Part	Gearbox/ variable drive Bearings Coupling to the driver Coupling to the driven unit Lubrication Seals	Casing Rotor with impellers Balance piston Interstage seals Radial bearing Thrust bearing Shaft seals Internal piping Valves Antisurge system [b] Piston Cylinder liner Packing	Actuating device Control unit Cables and junction boxes Internal power supply Monitoring Sensors [a] Valves Wiring Piping Seals	Oil tank with heating system Pump Motor Check valves Coolers Filters Piping Valves Lube oil	Oil tank with heating Reservoir Pump Motor Gear Filters Valves Seal oil Dry gas seal Mechanical seal Scrubber	Base frame Piping, pipe support and bellows Control valves Isolation valves Check valves Coolers Silencers Purge air Magnetic-bearing control system Flange joints

[a] Specify type of sensor, e.g. pressure, temperature, level, etc.

[b] Including recycle valve and controllers.

Construction of Technical Hierarchy
Equipment Properties for Compressors (subset)

Table A.10 — Equipment-specific data — Compressors

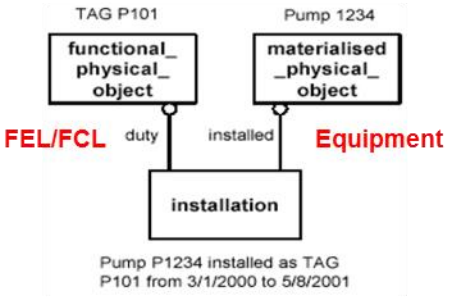
Name	Description	Unit or code list	Priority
Compressed medium	Gas or air compressor	Gas, air	High
Type of driver	Driver unit (equipment class, type and identification code)	Specify	High
Gas handled	Average molar mass (specific gravity × 28,96)	Grams per mole	Medium
Suction pressure	Design – first stage	Pascal (bar)	Medium
Suction pressure	Operating – first stage	Pascal (bar)	Low
Discharge pressure	Design – last stage	Pascal (bar)	High
Discharge pressure	Operating – last stage	Pascal (bar)	Medium
Flow rate	Design	Metres cubed per hour	High
Flow rate	Operating	Metres cubed per hour	Low
Discharge temperature	Design	Degrees Celsius	Medium
Discharge temperature	Operating	Degrees Celsius	Low
Power	Design power	Kilowatt	High
Utilization	Percent utilization compared to design	Percent	Medium

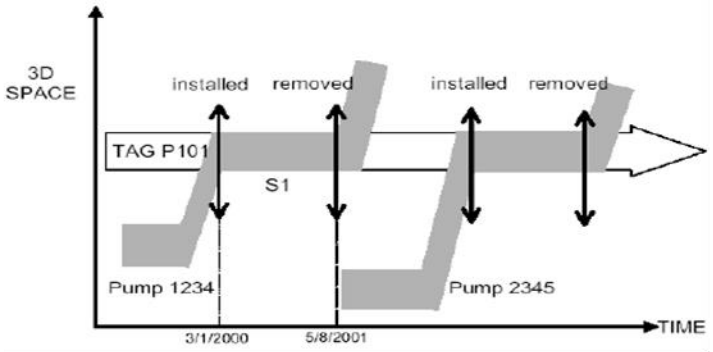
Functional Location / Equipment Relationship ISO 15926-2, Section E.3.3

Functional equipment location Tag P101 is an intangible object that defines process requirements for a particular pumping service, e.g. pressure, temperature, flow, fluid type (Tag P101 in the example below)

Equipment items (serial numbers 1234 and 2345) define specific materialized objects that execute process requirements

Field equipment change-outs are captured in SAP via corresponding equipment dismantle/installation transactions (on 5/8/2001 S/N 1234 was dismantled and S/N 2345 installed)



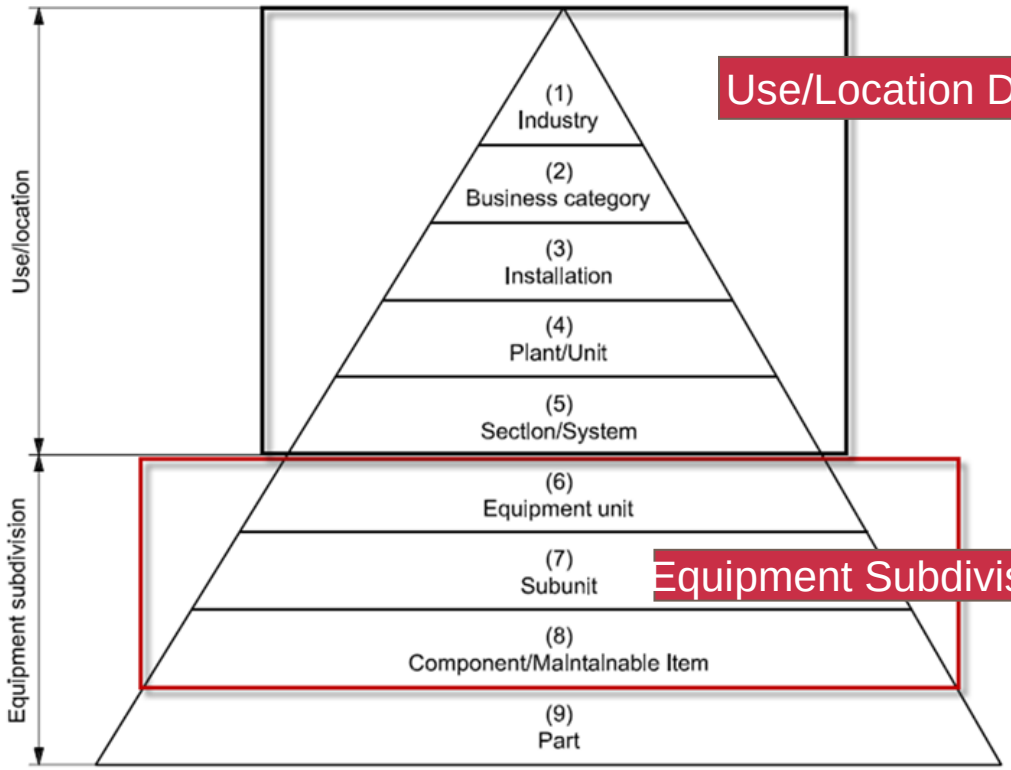


The duty represented by TAG P101, and Pump 1234 are coincident for the period of the installation, i.e. the state S1 of Pump 1234 that is installed as TAG P101 is in fact also a state of TAG P101. TAG P101 consists of those states of the pumps that are installed in this location.

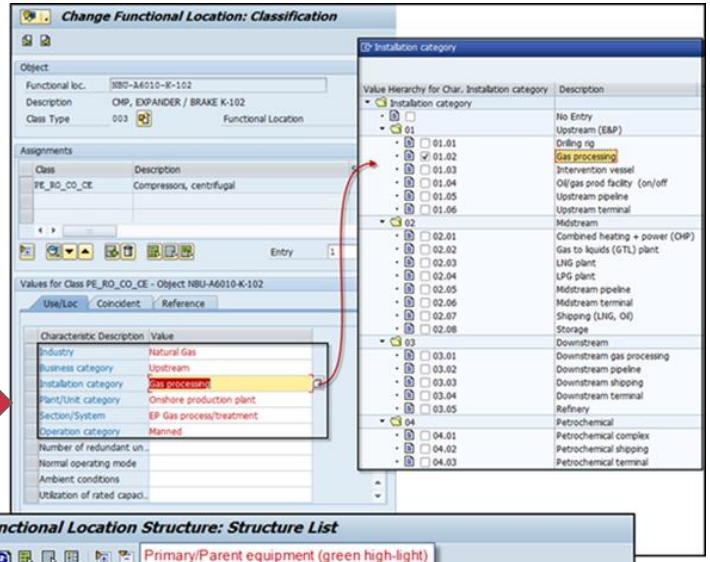
ISO 15926-2 (Data Model) Industrial automation systems and integration—Integration of life-cycle data for process plants including oil and gas production facilities, Figures E.9 and E.10.

ISO 14224 Technical Structure

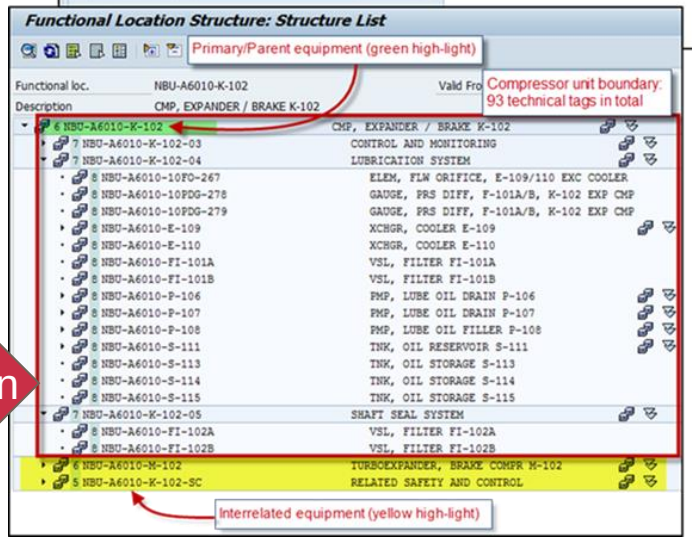
- ERP is system of record for all technical tags
- One unique ID for each tag throughout all systems, records, and in the field
- Equipment interrelationships defined in system



Use/Location Data



Equipment Subdivison



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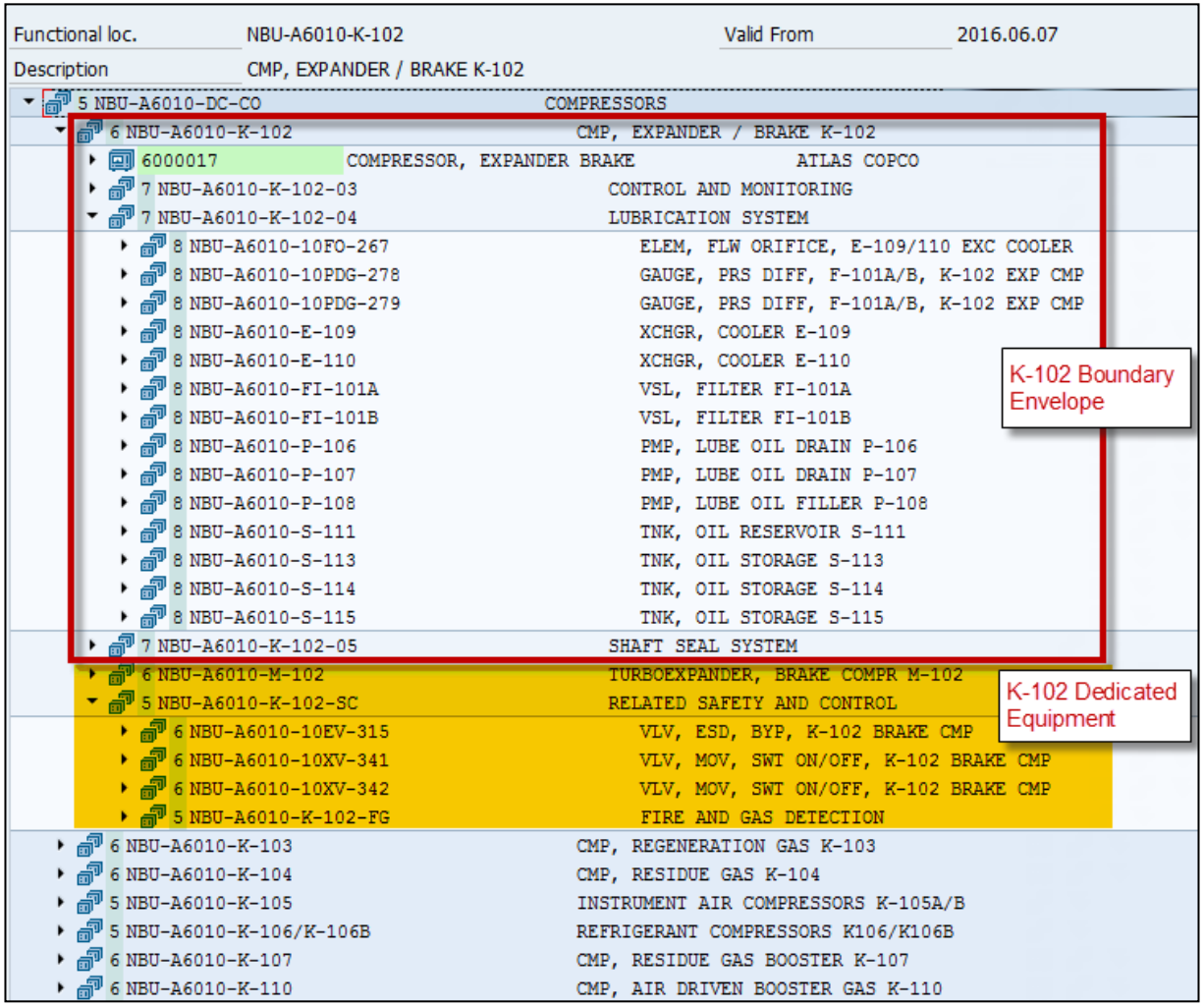
K-102 Boundary Definition



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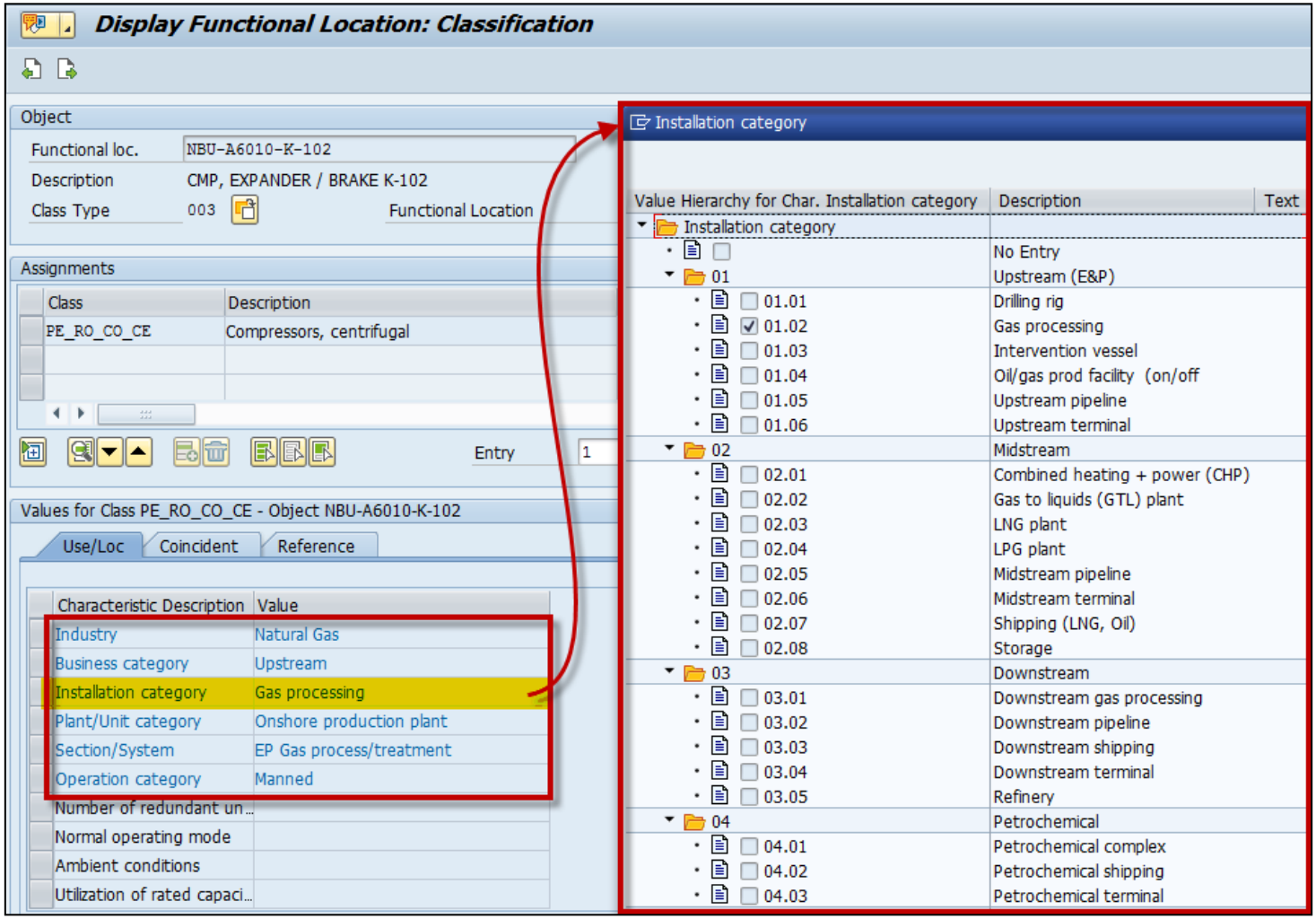
Use/Location Data



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Malfunction Reporting
Impart Data Quality on Inception

Step	Details	Responsibility
Work Initiation	Problem Report (equipment-level failure notations), system QA checks	Facility personnel
Approvals and processing	Work approval, planning and scheduling, create statistical records	Operations Superintendent
Execution, repair notes, and close-out	Repair Report (item-level failure notations), system QA checks	Maintenance Lead Technician
Failure data quality control	QA/QC, consequence assessment, and methods feedback	Reliability Engineer

Malfunction Problem Report (Work Initiation)
Equipment-Level Notations

9.5 Failure data

A uniform definition of failure and a method of classifying failures are essential when it is necessary to combine data from different sources (plants and operators) in a common RM database.

A common report, as given in Table 6 (see also Table 3), for all equipment classes shall be used for reporting failure data. For some equipment classes, e.g. subsea equipment, minor adaptations can be necessary.

The minimum data needed to meet the objectives of this International Standard are identified by (*). However, the addition of certain other data categories can significantly improve the potential usability of the RM data; see Annex D.

Table 6 — Failure data

Category	Data to be recorded	Description
Identification	Failure record (*)	Unique failure record identification
	Equipment identification/Location (*)	E.g. tag number (see Table 5)
Failure data	Failure date (*)	Date of failure detection (year/month/day)
	Failure mode (*)	Usually at equipment-unit level (level 6) (see B.2.6) [a]
	Failure impact on plant safety (e.g. personnel, environment, assets) [b]	Usually zero, partial or total
	Failure impact on plant operations (e.g. production, drilling, intervention) [b]	Usually zero, partial or total
	Failure impact on equipment function (*)	Effect on equipment-unit function (level 6): critical, degraded, or incipient failure [c]
	Failure mechanism	The physical, chemical or other processes which have led to a failure (see Table B.2)
	Failure cause [d]	The circumstances during design, manufacture or use which have led to a failure (see Table B.3)
	Subunit failed	Name of subunit that failed (see examples in Annex A)
	Component/Maintainable item(s) failed	Name of the failed maintainable item(s) (see Annex A)
	Detection method	How the failure was detected (see Table B.4)
	Operating condition at failure	Running, start-up, testing, idle, standby
Remarks	Additional information	Give more details, if available, on the circumstances leading to the failure: failure of redundant units, failure cause(s) etc.

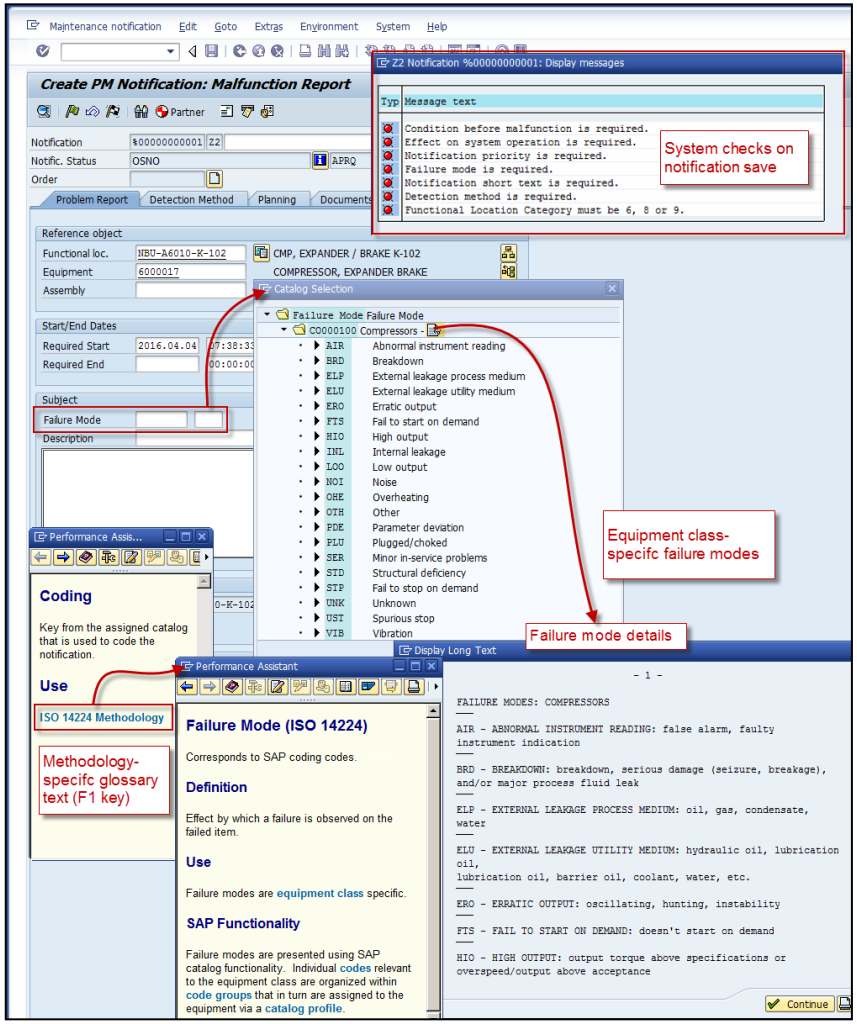
[a] For some equipment categories such as subsea equipment, it is recommended to also record failure modes on taxonomic levels lower than the equipment-unit level.

[b] See example of failure consequence classification in Table B.2.

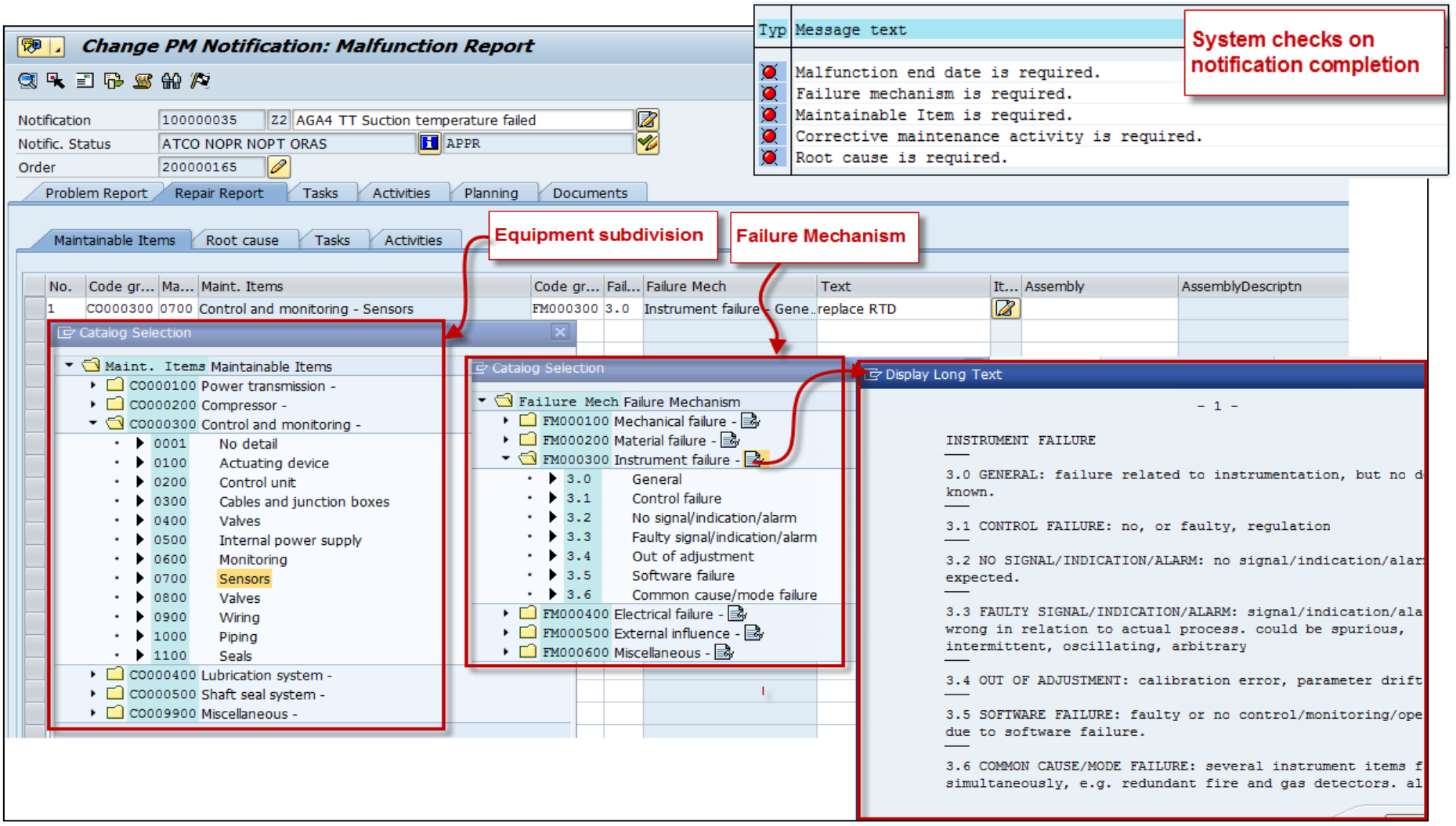
[c] For some equipment categories and applications it may be sufficient to record critical and non-critical (degraded + incipient) failures only.

[d] The failure cause and sometimes the failure mechanism are not known when the data are collected, as they commonly require a root cause analysis to be performed. Such analysis shall be performed for failures of high consequence, high repair/down time cost, or failures occurring significantly more frequent than what is considered "normal" for this equipment unit class ("worst actors").

(*) indicates the minimum data that shall be collected.



Malfunction Repair Report (Work Close-out)
Component-Level Notations



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Event Consequence Assessment

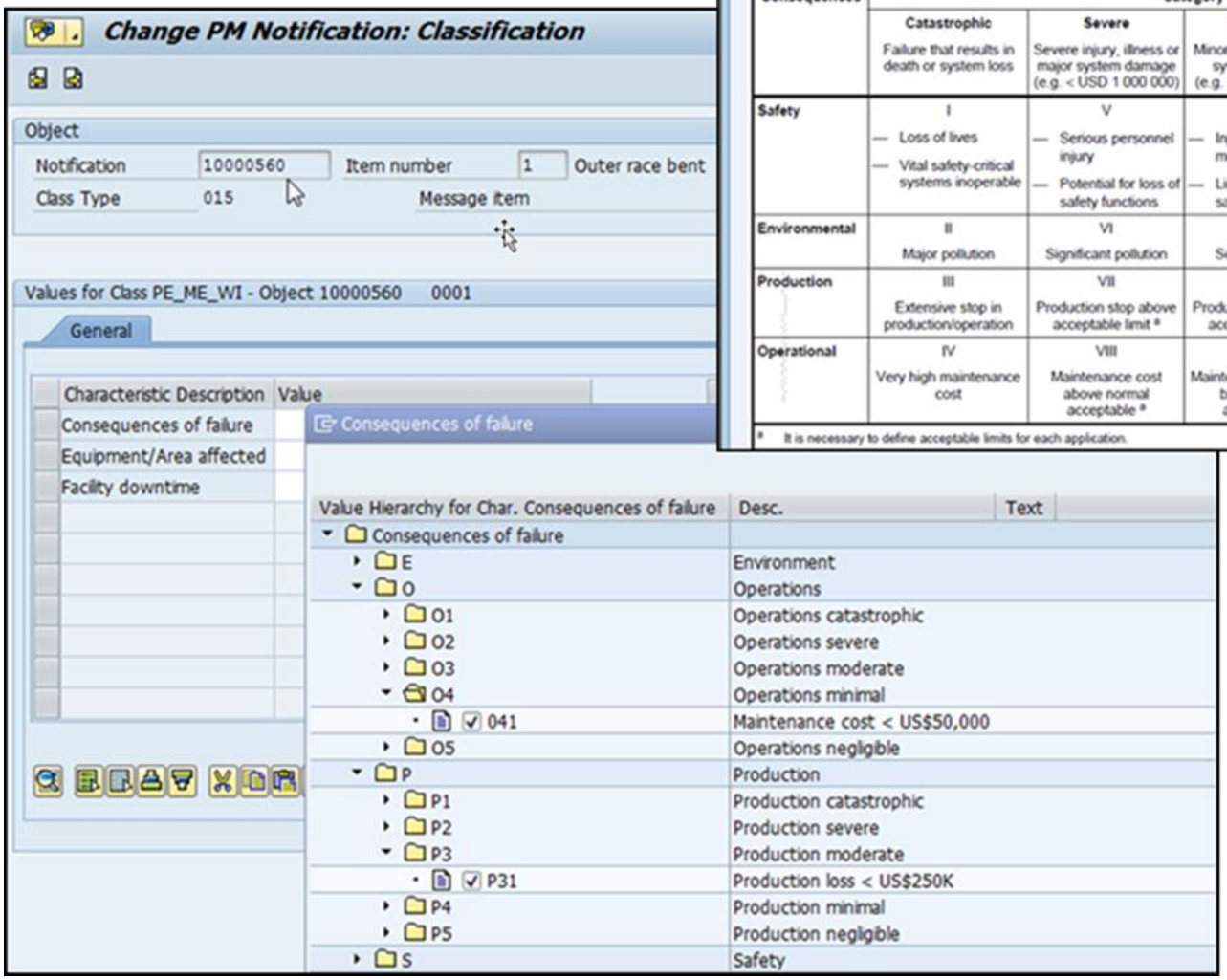

Table C.1.png - Windows Photo Viewer

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ISO 14224:2006(E)

Table C.1 — Failure-consequence classification

Consequences	Category			
	Catastrophic Failure that results in death or system loss	**Severe** Severe injury, illness or major system damage (e.g. < USD 1 000 000)	**Moderate** Minor injury, illness or system damage (e.g. < USD 250 000)	**Minor** Less than minor injury, illness or system damage (e.g. < USD 50 000)
Safety	I — Loss of lives — Vital safety-critical systems inoperable	V — Serious personnel injury — Potential for loss of safety functions	IX — Injuries requiring medical treatment — Limited effect on safety functions	XIII — Injuries not requiring medical treatment — Minor effect on safety function
Environmental	II Major pollution	VI Significant pollution	X Some pollution	XIV No, or negligible, pollution
Production	III Extensive stop in production/operation	VII Production stop above acceptable limit [a]	XI Production stop below acceptable limit [a]	XV Production stop minor
Operational	IV Very high maintenance cost	VIII Maintenance cost above normal acceptable [a]	XII Maintenance cost at or below normal acceptable [a]	XVI Low maintenance cost

[a] It is necessary to define acceptable limits for each application.

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Preventive Maintenance and Inspections

Program

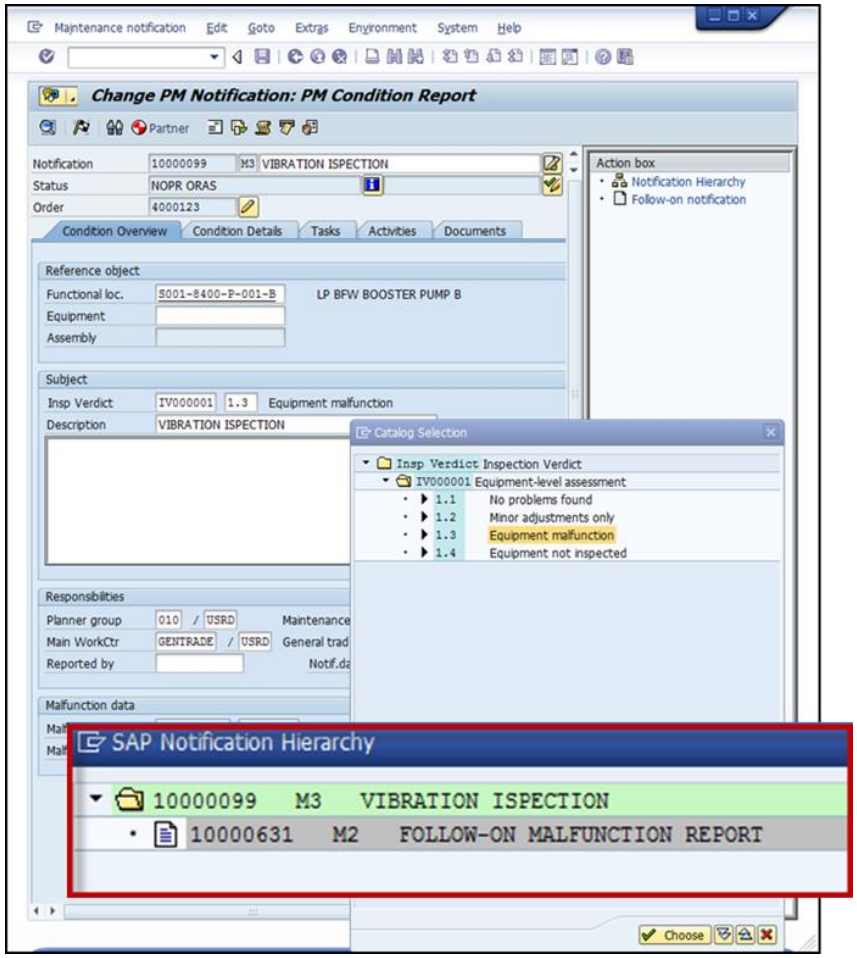
- Administered as administrative or technical tag level
- Results reported at technical tag level

PM Condition Report

- One condition report per technical tag inspected
- Inspection verdict and condition details
- Generated from object list of PM inspection order

Follow-on malfunction report

- Generated for any equipment malfunction verdict
- Linked to PM Condition Report as subordinate object



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Quality Control Processes

Review malfunction and condition reports to ensure completeness and a clear and concise description of what happened

Identify “non-malfunction” malfunction reports and set user status to exclude them from the failure data dataset

Review other ERP data to identify missing failure events, e.g. review materials booked against blanket orders of cost centers, review preventive maintenance and inspection results to ensure follow-on malfunction reporting was done, etc.

Identify and document follow-on requirements, e.g. preventive maintenance additions, facilities change requirements, SJP requirements

Circle-back with personnel when issues are found with completion of malfunction reports

Relevant International Standards

ISO 14224:2006

Petroleum, petrochemical and natural gas industries -- Collection and exchange of reliability and maintenance data for equipment

ISO 15926-2:2003

Industrial automation systems and integration -- Integration of life-cycle data for process plants including oil and gas production facilities -- Part 2: Data model

OREDA

Offshore Reliability Database, Joint Industry Project that developed ISO 14224

Thank you

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Reliability Dynamics LLC

Company overview

- Registered engineering company specializing in equipment reliability and maintenance solutions for corporate software systems
- Primary product is the Industry Standard Solution for Plant Maintenance (ISPM®)

Current and recent customers

- Brunei Methanol Company
- Precision Drilling
- Pembina Pipeline
- QGOG (Maximo)
- Maersk Drilling
- Nexen Inc
- Marathon Oil
- Fortis Alberta