

Reliability Dynamics

# Industry Standard Solution for Plant Maintenance (ISPM®)



# Objectives and Business Benefits:

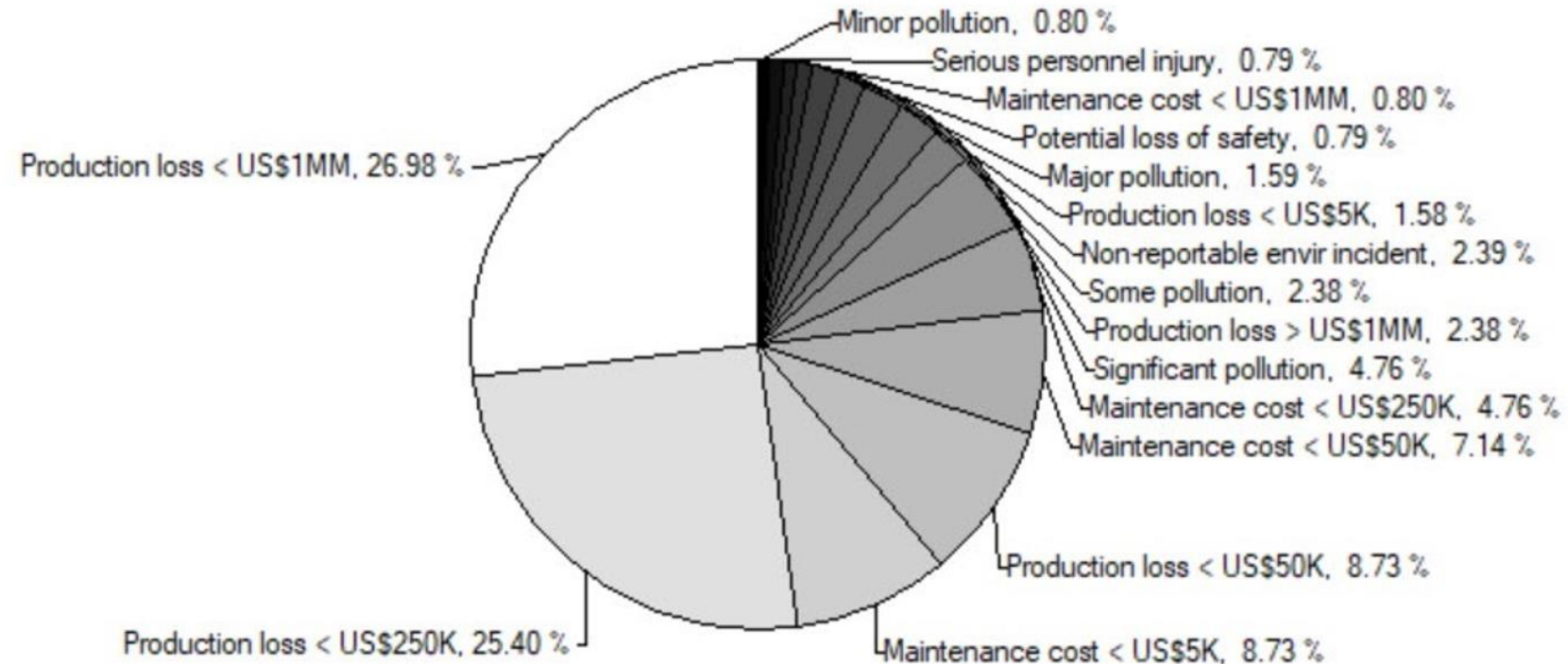
- Use high-quality equipment performance data to optimize equipment decisions and plant operations
- Reduce risk and improve production throughput and profitability



## Failure Events versus Consequences - Corporate<sup>1</sup>

# Key Business Metrics

- Corporate view of data
- Identify, analyze, and resolve equipment issues



### Notes

1. Value set adapted from ISO 14224:2016, Table C.2

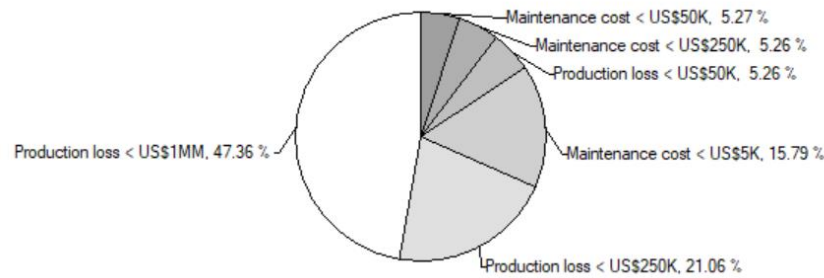


# Analyze

## Durco Pumps in Claus Service

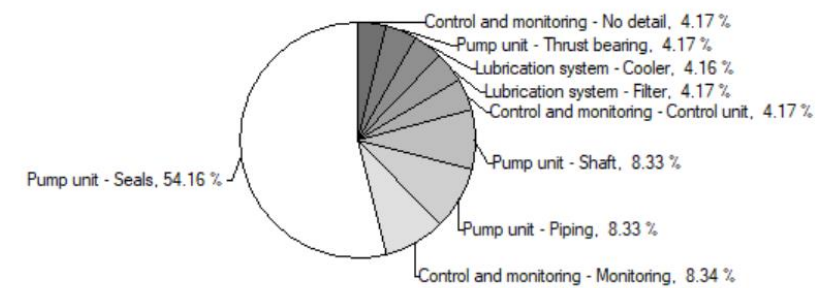
### Failure Consequences

Ref. ISO 14224:2016, Table C.2



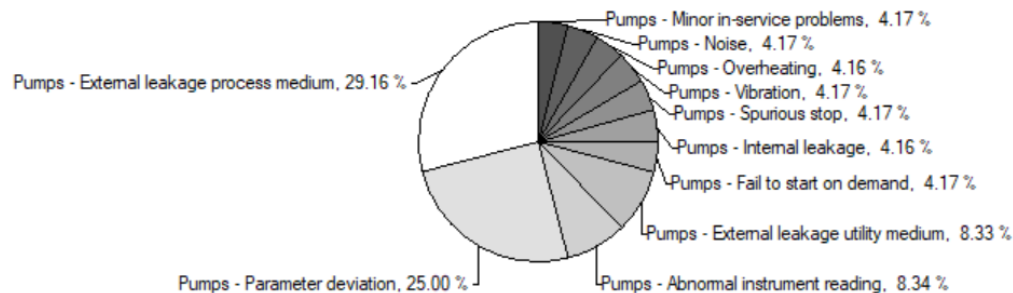
### Primary Failure Components

Ref. ISO 14224:2016, Table A.21



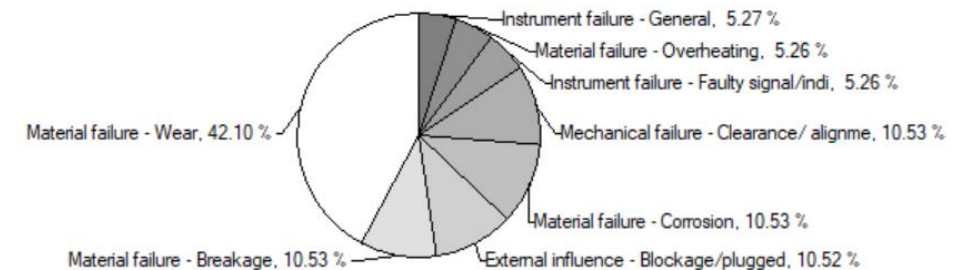
### Failure Modes

Ref. ISO 14224:2016, Table B.6



### Failure Mechanisms

Ref. ISO 14224:2016, Table B.2





# Problem

- While **Equipment performance data** support safety and reliability decisions,
  - High-quality data are unavailable, due to pervasive deficiencies in corporate software solutions
  - Low-quality data compromise equipment decisions, increase risk, and decrease profitability
  - AI and ML models are compromised; only as good as the data inputs



# Current Solutions are Nonviable

- While **ERP software** is capable, solutions for equipment performance data are consistently nonviable
- **Failure and maintenance event details** are impractical to reconstruct after time passes
- **Natural Language Processing (NLP)** cannot fix poor quality failure and maintenance event data
- **Industry databases and handbooks** compile low-quality data from a few individual companies



# Solution

1. **Taxonomy and data structure** for the digitalization of equipment performance data
2. **ERP software app** to make equipment performance data high-quality at inception

**LOWER  
COSTS**

Capital and operating  
costs

**DECREASE  
RISK**

Optimize inspection  
intervals

**INCREASE  
PRODUCTION**

Higher equipment  
availability



# Equipment Performance Data QM Cockpit

SAP Implementation Guide (IMG)

Display IMG

More

Structure

- Plant Maintenance and Customer Service
  - Master Data in Plant Maintenance and Customer Service
  - Maintenance Plans, Work Centers, Task Lists and PRTs
- Maintenance and Service Processing
  - Basic Settings
  - Maintenance and Service Notifications
    - Overview of Notification Type
    - Notification Creation
    - Notification Processing
      - Response Time Monitoring
      - Additional Functions
      - Notification Print Control
      - User Status for Notifications
      - Object Information
      - Condition Indicator
      - List Editing
      - ISPM Add-on
        - Equipment Reliability Data Quality Management Cockpit
          - Define Applicability
          - Define Field Validation Scope
          - Identify Functional Location Category Checks
          - Identify System Effects that Set the Breakdown Indicator
          - Specify User Status Defaults for ISPM
          - Define Superior Notification Relationship Types
        - Customize User Helps for ISPM
        - Set Workflow for Maintenance Notifications
        - Set Workflow for Service Notifications

Specify notification validations and their behavior

Change View "Notification Validations": Details

New Entries

MaintPlant

Notifictn type

M1

Table Name for check

Notification Header

Validn. Crit. Field

PRIOK

Check Type

Check on Completion

Notification Validations

Comparison Option

Not equal (<>)

Validn. - Field Val.

Check FEL Notifn

Error Text

Notification priority is required.

Notification Validation - Criteria Field (1) 237 Entries found

Restrictions

Table Name: VIQMEL

Field Name	Key	DType	Length	Short Description
MANDT	✓	CLNT	000003	Client
QMNUM	✓	CHAR	000012	Notification No
IWERK		CHAR	000004	Maintenance Planning Plant
ILOAN		CHAR	000012	Location and account assignment for technical object
ILOAI		CHAR	000001	ILOA Individual
EQUINR		CHAR	000018	Equipment Number
BAUTL		CHAR	000018	Assembly
EBORT		CHAR	000020	Installation Point for Subitem
MSAUS		CHAR	000001	Breakdown Indicator
AUSVN		DATS	000008	Start of Malfunction (Date)
AUSBS		DATS	000008	End of Malfunction (Date)
AUTD		TIME	000008	Start of Malfunction (Time)

237 Entries found

Data qualification control table

Notification Control Table

Plnt	Typ	Brkdown Dt	FEL Ntf Dt	Fn Loc Dt	Hd Chk Dt	Itm Chk Dt	Default Dt	FL.EqRf Dt
<input type="checkbox"/>	M1			2012.07.07	2012.07.07	2012.07.07	2012.07.07	2012.07.07
<input type="checkbox"/>	M2	2012.07.07	2012.07.07	2012.07.07	2012.07.08	2012.07.07	2012.07.07	2012.07.07
<input type="checkbox"/>	M3			2012.07.07	2012.07.07	2012.07.07	2012.07.07	2012.07.07
<input type="checkbox"/>	R1	2012.07.07					2012.07.07	
<input type="checkbox"/>	R2	2012.07.07		2012.07.07	2012.07.07	2012.07.07	2012.07.07	2012.07.07

Notification messages

Typ	Message text
●	Equipment condition before malfunction is required.
●	Effect on system operation is required.
●	Notification priority is required.
●	Failure mode is required.
●	Notification short text is required.
●	Detection method required.
●	Functional Location Category must be 6, 8 or 9.

Fields selections for specified table

Notification Validation - Criteria Field (1) 237 Entries found

Restrictions

Table Name: VIQMEL

Field Name	Key	DType	Length	Short Description
MANDT	✓	CLNT	000003	Client
QMNUM	✓	CHAR	000012	Notification No
IWERK		CHAR	000004	Maintenance Planning Plant
ILOAN		CHAR	000012	Location and account assignment for technical object
ILOAI		CHAR	000001	ILOA Individual
EQUINR		CHAR	000018	Equipment Number
BAUTL		CHAR	000018	Assembly
EBORT		CHAR	000020	Installation Point for Subitem
MSAUS		CHAR	000001	Breakdown Indicator
AUSVN		DATS	000008	Start of Malfunction (Date)
AUSBS		DATS	000008	End of Malfunction (Date)
AUTD		TIME	000008	Start of Malfunction (Time)

237 Entries found



# Technical Hierarchy Example

4	LLAK-8400	STEAM GENERATION
5	LLAK-8400-BG	BUILDINGS
5	LLAK-8400-CL	CONTROL UNITS
5	LLAK-8400-CR	CRANES, HOISTS, AND MONORAILS
5	LLAK-8400-FG	FIRE AND GAS DETECTORS
5	LLAK-8400-HB	OTSG STEAM GENERATORS
5	LLAK-8400-HE	EXCHANGERS
5	LLAK-8400-HT	HEAT TRACING
5	LLAK-8400-LI	LIGHTING
5	LLAK-8400-PD	POWER DISTRIBUTION
5	LLAK-8400-PI	8400 PIPING BY COMMODITY
5	LLAK-8400-PU	PUMPS
5	LLAK-8400-P-001	LP BFW BOOSTER PUMPS
5	LLAK-8400-P-002	HP BFW PUMPS
6	LLAK-8400-P-002-A	HP BFW PUMP A
10055213		PUMP-UTILITY GRADE, MULTISTAGE, RING SEC
7	LLAK-8400-P-002-A-02	PUMP UNIT
7	LLAK-8400-P-002-A-03	CONTROL AND MONITORING
7	LLAK-8400-P-002-A-04	LUBRICATION SYSTEM
8	LLAK-8400-E-010-A	COOLER-LUBE OIL-HP BFW PUMP
8	LLAK-8400-F-001-A	FILTER-LUBE OIL-BFW PUMP
8	LLAK-8400-P-004-A	PUMP, LUBE OIL, HP BFW PUMP
8	LLAK-8400-P-005-A	PUMP, LUBE OIL, HP BFW PUMP
8	LLAK-8400-P-006-A	PUMP, HP BFW PUMP AUXILIARY OIL
8	LLAK-8400-RS-001-A	RESERVOIR-LUBE OIL-BFW PUMP
5	LLAK-8421-CM-207	8400-P-005A HP BFW LUBE OIL
6	LLAK-8400-P-002-A-M	MOTOR-HP BFW PUMP A
6	LLAK-8400-CV-001-A	VALVE, CHECK - P-002-A DISCHARGE
6	LLAK-8400-P-002-B	HP BFW PUMP B

Pump boundary

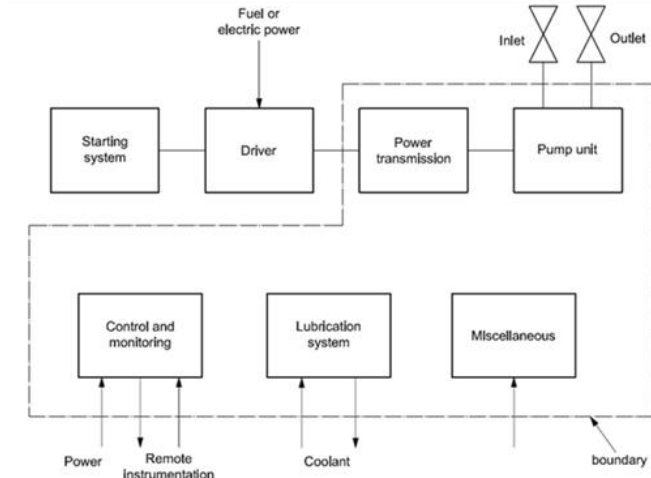


Figure A.7 — Boundary definition — Pumps

Table A.21 — Equipment subdivision — Pumps

Equipment unit	Pumps				
Subunit	Power transmission	Pump unit	Control and monitoring	Lubrication system	Miscellaneous
Maintainable items	Gearbox/variable drive Bearing Seals Coupling to driver Coupling to driven unit Belt/sheave	Support Casing Impeller Shaft Radial bearing Thrust bearing Seals Valves Piping Cylinder liner Piston Diaphragm	Actuating device Control unit Internal power supply Monitoring Sensors <sup>a</sup> Valves Wiring Piping Seals	Reservoir Pump Motor Filter Cooler Valves Piping Oil Seals	Purge air Cooling/heating system Cyclone separator Pulsation damper Flange joints

<sup>a</sup> Specify type of sensor, e.g. pressure, temperature, level, etc.

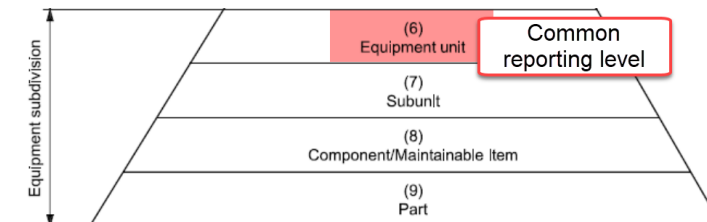


Figure 3 — Taxonomy classification with taxonomic levels



# Failure Report Example

- Specifications of required data per work category<sup>2,3,4</sup>
- Discrete fields with structured input for each required data<sup>1,2</sup>
- System-validations to ensure compliance with specifications

## Notes - ISO 14224:2016

1. Table 6 – Failure data
2. Table 8 – Maintenance data
3. Table 3 – Reliability and maintenance parameters in relation to taxonomy levels

**System validation of compliance with ISO 14224:2016, Tables 3, 6, and 8**

**Value set from ISO 14224:2016, Table B.6**

**Reliability and maintenance terms, from ISO 14224:2016, Clause 3**

**Failure Mode Failure mode coding**

- PU000100 Pumps -
- AIR Abnormal instrument reading
- BRD Breakdown
- ELP External leakage process medium
- ELU External leakage utility medium
- ERO Erratic output
- FTS Fail to start on demand
- HIO High output
- INL Internal leakage
- LOO Low output
- NOI Noise
- OHE Overheating
- OTH Other
- PDE Parameter deviation
- PLU Plugged/choked
- SER Minor in-service problems
- STD Structural deficiency
- UNK Unknown
- UST Spurious stop
- VIB Vibration

**ISO 14224 Methodology**

1. Incipient/impending failure: imperfection in the state or condition of an item so that a degraded or critical failure might (or might not) eventually be the expected result if corrective actions are not taken.

a) No affect to throughput, but increased probability of equipment unit failure, e.g. failure of one or more redundant ancillary components, increased vibration, or insufficient pipe wall thickness.

2. Degraded function: failure that does not cease the fundamental function(s), but compromises one or several functions.

**Effect on Operation**

Effect of the problem or malfunction on the operation of the affected system

**Use**

**ISO 14224 Methodology**

**Incipient/impending failure**

**Degraded function**

**Critical failure-shutdown/forced outage**

**Effect on the system**

Funct. loc. affected LLAk-8400-P-002-A

Effect 3 Critical failure-shutdown/forced outage

**System avail**

SCn C

1 Running / Online

2 Start-up

3 Testing

4 Idle

5 Hot standby

6 Cold Standby

7 Run-down

Cond.bef.malfunction 2 Start-up

Malfunct. sta 20:08:16 Breakdown

Malfunct.en 00:00:00 Breakdown dur.

**Message text**

- Equipment condition before malfunction is required.
- Effect on system operation is required.
- Notification priority is required.
- Failure mode is required.
- Notification short text is required.
- Detection method required.
- Functional Location Category must be 6, 8 or 9.




# The ISPM Add-on for SAP

- SAP solution extension, [certified for S/4HANA](#) On-premise and Cloud
- ISO 14224:2016 compliant<sup>1</sup>
- 19 years of application in industry
- Patented system and methods ([US011157519](#))

---  
Notes:

1. Compliant with ISO/TC67/WG4/PG1 guidance to industry, in ISO Course [Use of ISO 14224 for optimizing Safety and Profitability in the Oil and Gas Industry – in a digitalized perspective.](#)

  
 US011157519B2

(12) **United States Patent**  
Ciliberti, III

(54) **SYSTEM AND METHOD FOR ENTERPRISE ASSET MANAGEMENT AND FAILURE REPORTING**

(71) Applicant: **Vito Anthony Ciliberti, III**, South Bend, IN (US)

(72) Inventor: **Vito Anthony Ciliberti, III**, South Bend, IN (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 524 days.

(21) Appl. No.: **15/810,168**

(22) Filed: **Nov. 13, 2017**

(65) **Prior Publication Data**  
US 2018/0068007 A1 Mar. 8, 2018

**Related U.S. Application Data**

(63) Continuation of application No. 13/753,495, filed on Jan. 29, 2013, now abandoned.

(51) **Int. Cl.**  
*G06F 16/28* (2019.01)  
*G06Q 10/06* (2012.01)

(52) **U.S. Cl.**  
CPC ..... *G06F 16/284* (2019.01); *G06Q 10/0631* (2013.01); *Y02P 90/80* (2015.11)

(58) **Field of Classification Search**  
CPC ... *G06F 16/284*; *G06Q 10/0631*; *Y02P 90/80*; *Y02P 90/80*

See application file for complete search history.

(10) **Patent No.:** **US 11,157,519 B2**

(45) **Date of Patent:** **Oct. 26, 2021**

(56) **References Cited**  
U.S. PATENT DOCUMENTS

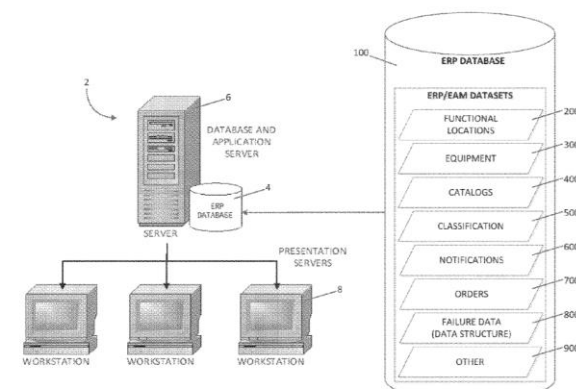
2003/0198180 A1*	10/2003	Cambon	.....	H04J 3/14
2005/0007249 A1*	1/2005	Eryurek	.....	G05B 23/027
2006/0241907 A1*	10/2006	Armstrong	.....	G05B 23/0218
2007/0035398 A1*	2/2007	Vesel	.....	G05B 23/0216
2009/0077055 A1*	3/2009	Dillon	.....	340-572.1
2012/0123951 A1*	5/2012	Hyatt	.....	G06F 16/337
				G06Q 10/10
				705/305

\* cited by examiner

**Primary Examiner** — Alford W Kindred  
**Assistant Examiner** — Lin Lin M Huay  
**(74) Attorney, Agent, or Firm** — Crump Law P.C.

(57) **ABSTRACT**  
 An information (ERP/EAM) system and equipment taxonomy for representing and managing of equipment, equipment subunits and component parts thereof across an enterprise that maps materialized physical objects to functional physical objects within a hierarchy of functional locations within the enterprise for all enterprise assets in accordance with applicable industry standards. The ERP/EAM system and the equipment taxonomy also provide multi-level failure reporting.

**9 Claims, 60 Drawing Sheets**



The diagram illustrates the system architecture. At the top, a 'SERVER' (labeled 2) is connected to a 'DATABASE AND APPLICATION SERVER' (labeled 6). The 'SERVER' is also connected to three 'WORKSTATION' units (labeled 8). The 'DATABASE AND APPLICATION SERVER' is connected to an 'ERP DATABASE' (labeled 100). The 'ERP DATABASE' contains several 'ERP/EAM DATASETS' (labeled 200), including: 'FUNCTIONAL LOCATIONS' (300), 'EQUIPMENT' (400), 'CATALOGS' (500), 'CLASSIFICATION' (600), 'NOTIFICATIONS' (700), 'ORDERS' (800), 'FAILURE DATA (DATA STRUCTURE)' (900), and 'OTHER' (900). The 'SERVER' is also connected to 'PRESENTATION SERVERS' (labeled 8).



# Customers

**Graham Macleod, Vice President of Asset Integrity and QMS, Precision Drilling**

*"I really liked the way that [Reliability Dynamics] interpreted a complex standard [ISO 14224] in relation to our application...it was exactly what we were looking for...its simplicity [for users] is what makes it great...insights from our [data/reports] are absolutely everything we possibly need."*



Organization	Software	Work Scope
US Department of Energy	SAP	Add-on software and content implementation for Strategic Petroleum Reserves
Precision Drilling	SAP	Add-on content and configuration, corporate-global
Pembina Pipeline	SAP	Add-on software and content, corporate-global
QGOG-Constellation	Maximo	Content and methods, offshore drilling fleet
Maersk Drilling	SAP	Taxonomy definition development for offshore drilling equipment
Nexen Energy	SAP	1. Content and methods implementation for Yemen Masila Block, methods later adopted corporate-wide 2. Technical hierarchy restructuring for Long Lake Facility (oil sands)
Marathon Oil	SAP	Content and methods for corporate template development and implementation for Alvheim FPSO
Fortis-Alberta	SAP	Failure reporting and warranty management for AMI



# Case History: The Nexen Masila Block

Nexen used ISO 14224 methods to increase Masila Block profits by US \$8.2 million annually

- Reduced maintenance costs for field power gen units by 64%
- Increased associated oil production by 53%



Digital Analytics and Condition-Based Maintenance Net \$8.2 Million Annually for...

Tony Ciliberti PE on LinkedIn

Overview The Masila Block Oil Field is in the Yemen Hadhramaut Desert. Oil production...

 13 • 4 Comments



# Thank you

**Tony Ciliberti PE**

US Expert ISO/TC67/WG4 Reliability engineering & technology  
Principal Engineer, Reliability Dynamics





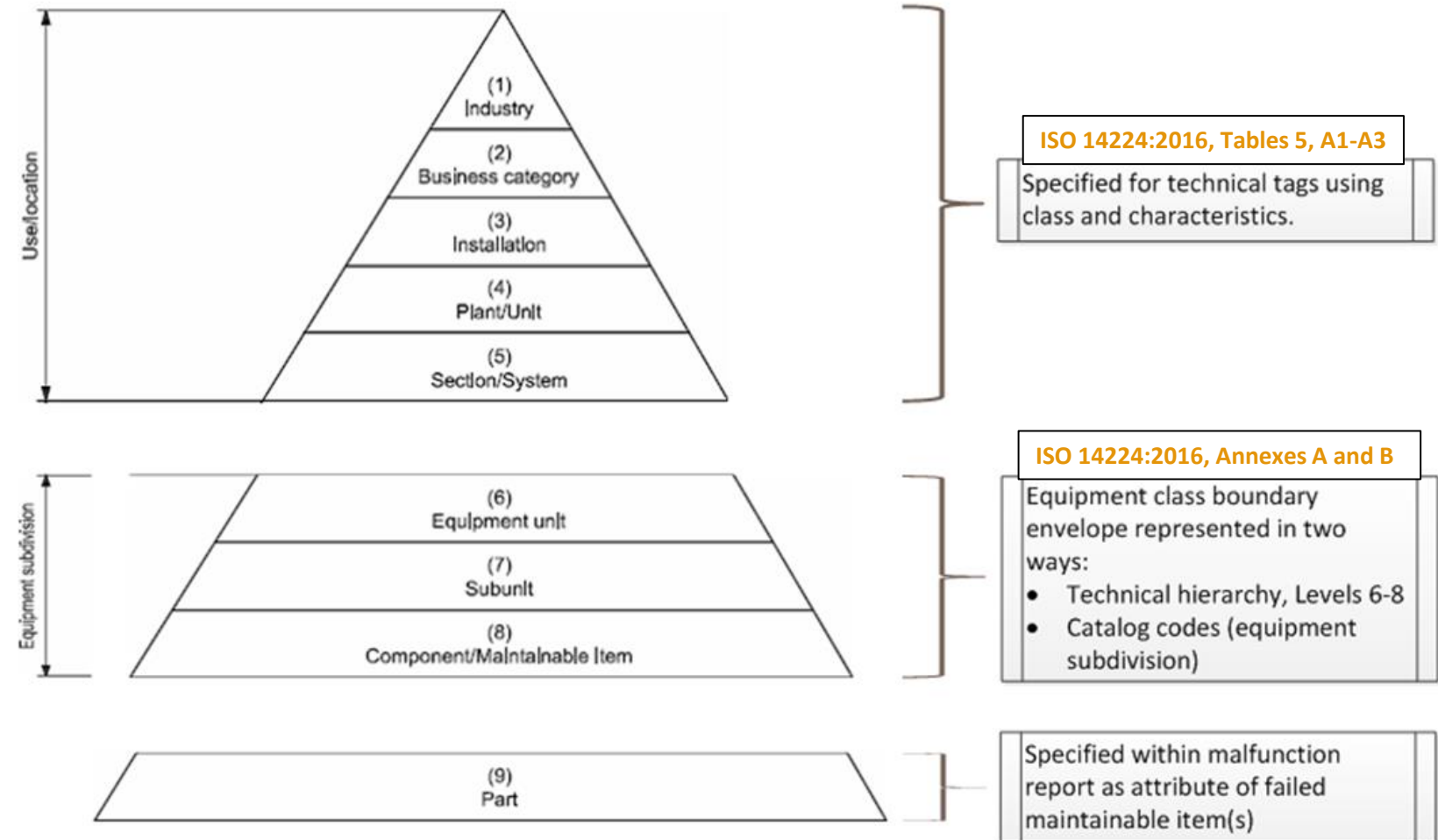
# ISPM Master Data Overview



# ISPM/ISO 14224

## Data Mapping

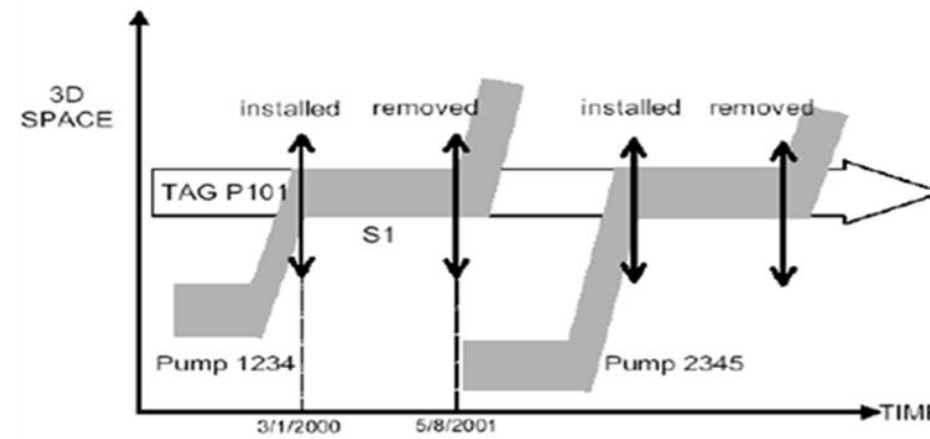
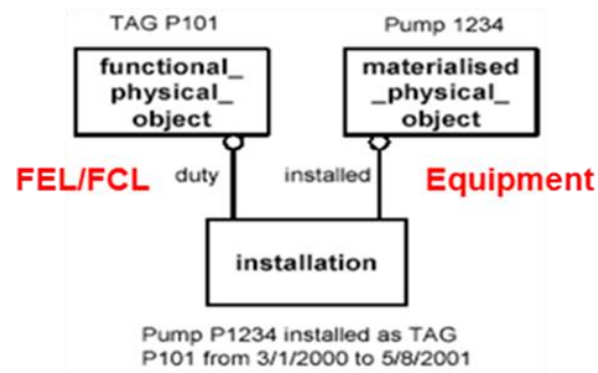
ISO 14224:2016 Figure 3 — Taxonomy classification with taxonomic levels





# Functional Location / Equipment Relationship

## ISO 15926-2:2003, Section E.3.3<sup>1</sup>



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.

1. ISO 15926-2, Section E3.3 is referenced in ISO 14224:2016, Table 5, Footnote b.



# Classification Structure

## Class Structure

EQ	All equipment
GP	General application
NP	Non process equipment
PE	Process equipment
PE_CO	Communications Equipment
PE_ME	Mechanical
PE_ME_AT	Atmospheric tanks
PE_ME_BU	Buildings
PE_ME_CR	Cranes
PE_ME_HE	Heat exchangers
PE_ME_LA	Loading arms
PE_ME_OC	Overhead cranes
PE_ME_PI	Piping
PE_ME_SE	Steam ejectors
PE_ME_SW	Swivels
PE_ME_WI	Winches
PE_ME_WS	Water screen systems
PE_ME_CP	Compactors, agglomeration
PE_ME_CP_FL	Compactors, floating gap
PE_ME_CP_FI	Compactors, fixed gap
PE_ME_CV	Conveyors
PE_ME_HB	Heaters and boilers
PE_ME_HS	Hoses
PE_ME_MB	CALM buoys (SPM)
PE_ME_PL	Pipeline
PE_ME_TA	Storage tanks
PE_ME_TU	Turrets
PE_ME_VE	Vessels
PE_EL	Electrical
PE_HS	HSE equipment
PE_LA	Lifting appliances
PE_RO	Rotating equipment

## Characteristics: Compactors, functional

A	B	C	D
1	Characteristic Name	Char. description	Characteristic Inherited
2	MAX_PRESSING_FORCE	Maximum pressing force	
3	ROLLER_DIAMETER	Roller diameter	
4	EXTRUSION_THICKNESS	Extrusion thickness	
5	ROLLER_SPEED_RANGE	Roller speed range	
6	ROLLED_SHEET_OUTPUT_MAX	Maximum rolled sheet output	
7	GRANULAR_SIZE_RANGE	Maximum granular size	
8	FINAL_PRODUCT_OUTPUT_MAX	Maximum product output	
9	TOTAL_MAIN_DRIVE_POWER	Total main drive power	
10	INDUSTRY	Industry	EQ
11	BUSINESS_CATEGORY	Business category	EQ
12	INSTALLATION_CATEGORY	Installation category	EQ
13	PLANT_UNIT_CATEGORY	Plant/Unit category	EQ
14	SECTION_SYSTEM	Section/System	EQ
15	OPERATION_CATEGORY	Operation category	EQ
16	NO_REDUNDANT_UNITS	Number of redundant units	EQ
17	NORMAL_OPERATING_MODE	Normal operating mode	EQ
18	AMBIENT_CONDITIONS	Ambient conditions	EQ
19	UTILIZATION_OF_CAPACITY	Utilization of rated capacity	EQ
20	RELEVANT_STANDARDS	Relevant Standards and Regs	EQ
21	PID_NUMBER	Process and Instr. Diagram No.	EQ
22	LEGACY_ID	Legacy ID	EQ

Value set adapted from ISO 14224:2016, Table A.4

## Value set: Section/System

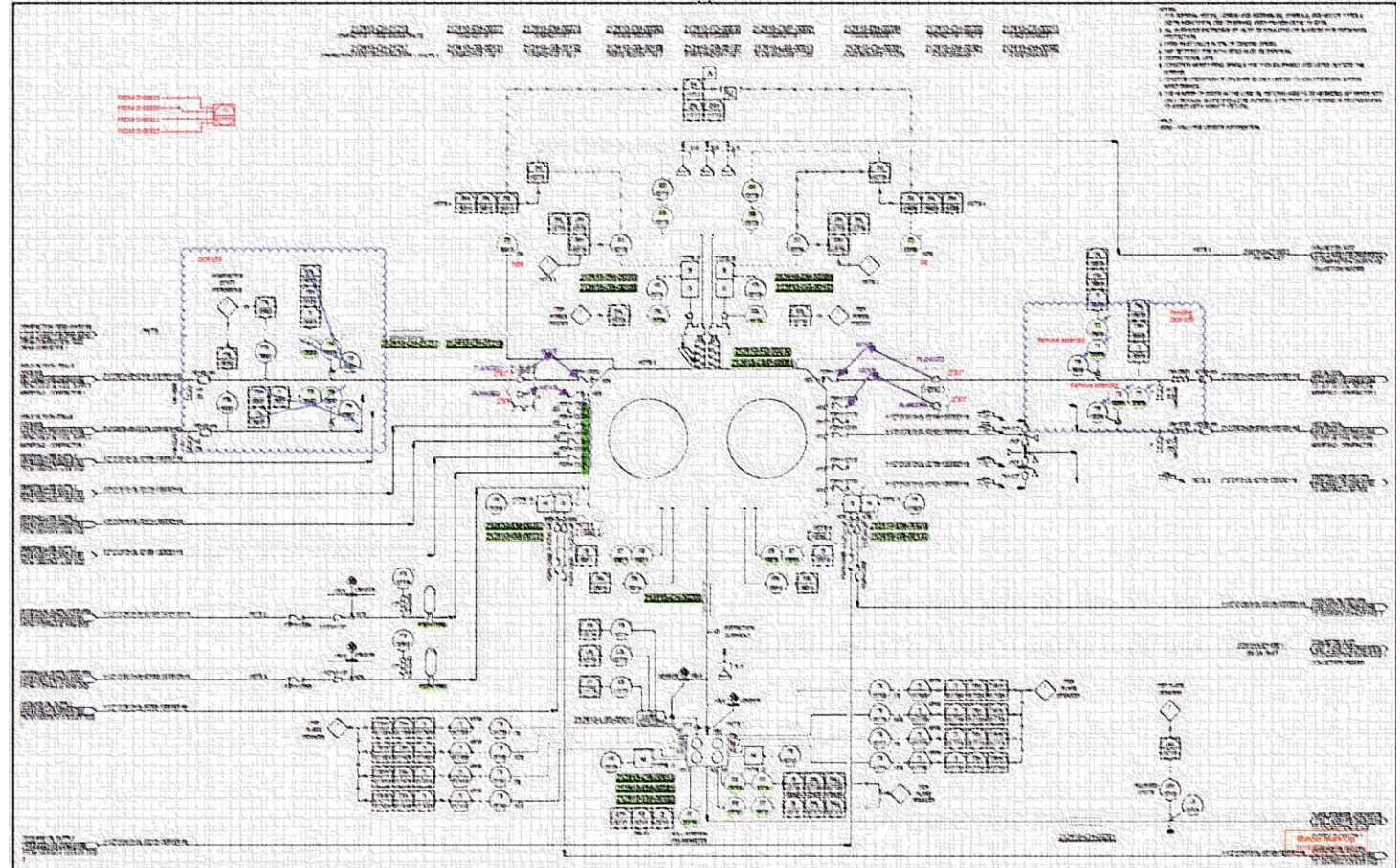
SECTION_SYSTEM	
Display Hierarchy	Description
> 06	General utilities
> 07	Auxiliaries
> 08	Fertilizer
> 08.01	Mining and extraction (ME)
> 08.01.01	ME Sub-Surface
> 08.01.02	ME Hydro
> 08.01.03	ME Surface
> 08.01.04	ME In-situ Leaching
> 08.01.05	ME Dredging
> 08.02	Processing plant
> 08.02.01	Ore crushing and pre-screening
> 08.02.02	Ore milling and pre-sizing
> 08.02.04	Sylvite flotation
> 08.02.05	NaCl leaching from floatn conc
> 08.02.06	Hydro-thkg & dehy of tailings
> 08.02.07	Hydro-sizing & dehy of conc
> 08.02.08	Concentrate drying
> 08.02.09	Preparation of chemicals
> 08.02.10	Granulation of KCL
> 08.02.11	Granules refining



# Construction of Technical Hierarchy

## Example

- Compile a tabular list of all technical tags from engineering drawings, SCADA, etc.





# Equipment Boundary for Compactors

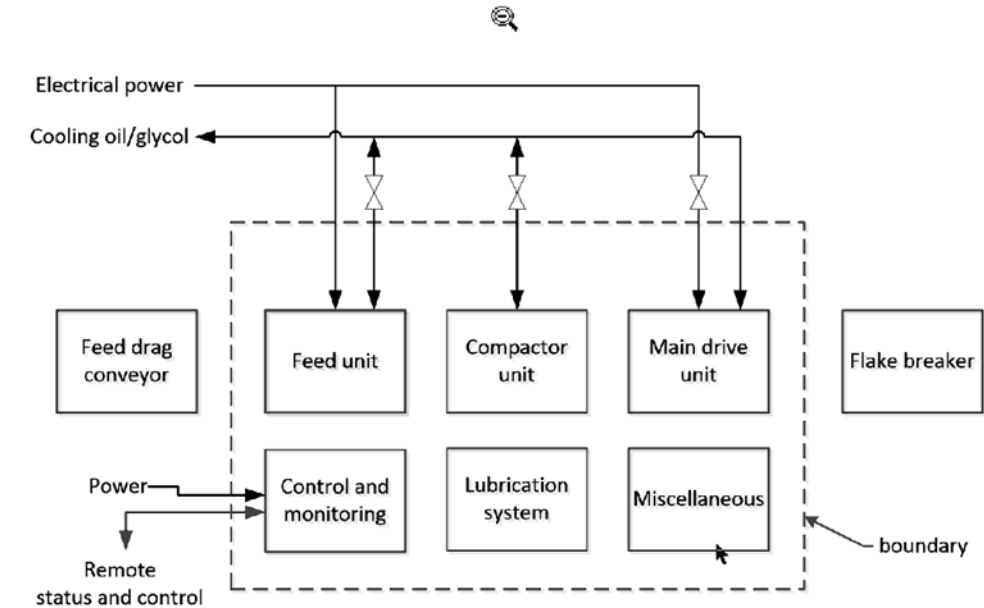
## Extended ISO 14224:2016 Content

- Determine which tags numbers are within the equipment boundary

### Equipment Class: Compactors, agglomeration

Taxonomy ID: PE\_ME\_CP

Equipment Types	Taxonomy ID
Compactors, fixed gap	PE_ME_CP_FI
Compactors, floating gap	PE_ME_CP_FL



Boundary definition – Compactors



# Equipment Subdivision for Compactors

1. Identify the main unit
2. Map component tags into subunits
3. Assign subunit structures to the main unit

AGCO0100 Compactors		AGCO0400 Control and monitoring	
SCG	SCG_TXT	CODE	MITXT
AGCO0100 Feed unit		0001	No detail
CODE	MITXT	0100	Actuating device
0001	No detail	0200	Control unit
0100	Frame and housing	0300	Internal power supply
0200	Force feeder screw	0400	Monitoring
0300	Drive motor	0500	Sensors
0400	Gearbox	0600	Valves
0500	Drive coupling	0700	Wiring
0600	Inspection/Access door	0800	Piping
AGCO0200 Main drive unit		0900	Seals
CODE	MITXT	AGCO0500 Lubrication system	
0001	No detail	CODE	MITXT
0100	Motor	0001	No detail
0200	Gearbox	0100	Heater
0300	Motor base	0200	Reservoir(s)
0400	Shaft guard	0300	Pump(s)
0500	Footing/Mounting	0400	Motor
AGCO0300 Compactor unit		0500	Filter
CODE	MITXT	0600	Temperature control
0001	No detail	0700	Valves
0100	Roll	0800	Piping
0200	Roll bearings	0900	Oil cooler
0300	Hydraulic system	1000	Oil
0400	Frame and housing	1100	Sensors
0500	Discharge chute	1200	Wires
0600	Inspection/Access door	AGCO9900 Miscellaneous	
		CODE	MITXT
		0001	No detail
		0100	Baseplate
		0200	Foundation
		0900	Other



# Compactor 1 Boundary Definition in the Technical Hierarchy

<input type="checkbox"/>	4	4013.11.24	COMPACTION	
<input type="checkbox"/>	5	4013.11.24.04	COMPACTION 1 PROCESS	
<input type="checkbox"/>	6	212410-CMP-0001	COMPACTOR 1	MI_AG_CP
<input type="checkbox"/>	>	10127672	Compactor, 1600-HP	
<input type="checkbox"/>	>	7 212410-CMP-0001-01	FEED UNIT	
<input type="checkbox"/>	✓	7 212410-CMP-0001-02	MAIN DRIVE UNIT	
<input type="checkbox"/>	>	8 212410-GB-00131	COMPACTOR 1 GB 1	PE_RO_GB
<input type="checkbox"/>	>	8 212410-GB-00132	COMPACTOR 1 GB 2	PE_RO_GB
<input type="checkbox"/>	✓	7 212410-CMP-0001-03	COMPACTOR UNIT	
<input type="checkbox"/>	>	8 212410-CH-00200	CHUTE, COMPACTOR 1	PE_ME
<input type="checkbox"/>	>	8 212410-CMP-0001-R1	FLOATING ROLL ASSY 1, COMPACTOR 1	PE_ME
<input type="checkbox"/>	>	8 212410-HPU-0001	COMPACTOR 1 HYDRAULIC POWER UNIT	UT_ME_HP
<input type="checkbox"/>	>	7 212410-CMP-0001-04	CONTROL AND MONITORING	
<input type="checkbox"/>	>	7 212410-CMP-0001-05	LUBRICATION SYSTEM	
<input type="checkbox"/>	✓	6 212410-CR-00013	FLAKE BREAKER 1	PE_ME
<input type="checkbox"/>	>	10127678	FLAKE BREAKER	
<input type="checkbox"/>	>	7 212410-CR-00013-04	CONTROL, PROTECTION, AND MONITORING	

Equipment boundary



# Equipment-Specific Data for Compactors

For each technical tag, assign:

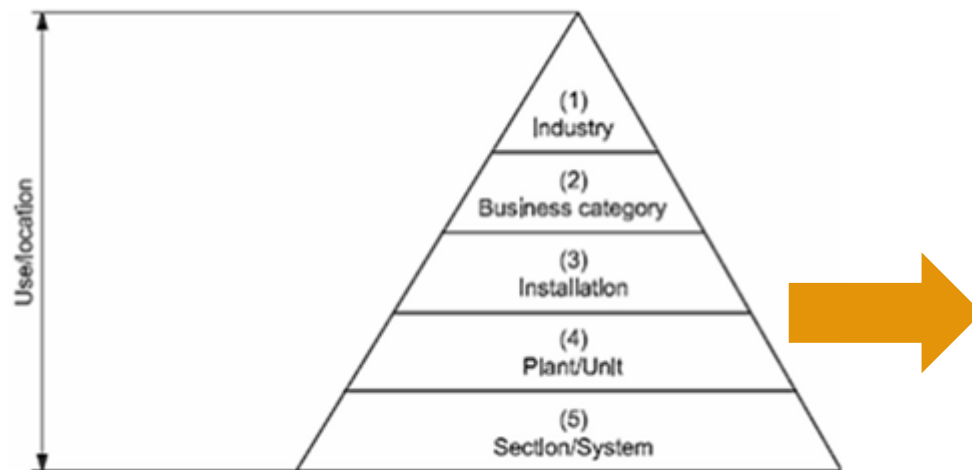
- Relevant classification ID
- Use/Location and equipment specific characteristics
- Reference examples in ISO 14224:2016, Table 5 and Annex A

PE_ME_CP      Compactors, agglomeration					
Characteristic ID/Char. Values	Descriptions	UOM	APPL	PR	
FINAL_PRODUCT_OUTPUT_MAX	Maximum product output	kg/h	CO	H	
GRANULAR_SIZE_RANGE	Maximum granular size	mm	CO	H	
MAX_PRESSING_FORCE	Maximum pressing force	kN	CO	H	
TOTAL_MAIN_DRIVE_POWER	Total main drive power	KW	CO	H	
ROLLER_SPEED_RANGE	Roller speed range	rpm	CO	H	
NUMBER_MAIN_DRIVE_MOTORS	Number of main drive motors	EA	EQ	H	
ROLLER_DIAMETER	Roller diameter	mm	CO	M	
EXTRUSION_THICKNESS	Extrusion thickness	mm	CO	M	
ROLLED_SHEET_OUTPUT_MAX	Maximum rolled sheet output	kg/h	CO	M	
MAIN_DRIVE_MOTORS_TYPE	Main drive motors type		EQ	M	
01	Electrical				
02	Hydraulic				




# Use/Location Data Assigned to All Tag Numbers

- Compliant with ISO 14224 taxonomy classification
- Structured data input
- Standard schemata



Object

Functional loc.	212410-CMP-0001
Description	COMPACTOR 1
Class Type	003  Functional Location

Assignments

Class	Description
<input type="checkbox"/> PE_ME_CP_FL	Compactors, floating gap

Values for Class PE\_ME\_CP\_FL - Object 212410-CMP-0001

Use/Loc    Coincident    Reference

Characteristic Description	Value
<input type="checkbox"/> Industry	Fertilizer
<input type="checkbox"/> Business category	Potash
<input type="checkbox"/> Installation category	Muriate of Potash (MOP)
<input type="checkbox"/> Plant/Unit category	Processing plant
<input type="checkbox"/> Section/System	Ore crushing and pre-screening
<input type="checkbox"/> Operation category	Manned
<input type="checkbox"/> Number of redundant units	2 EA
<input type="checkbox"/> Normal operating mode	Intermittent
<input type="checkbox"/> Utilization of rated capacity	100 %
<input type="checkbox"/> Ambient conditions	Outdoors-not enclosed

Value Hierarchy for Char...

	Desc.
<input type="checkbox"/> <input checked="" type="checkbox"/> Plant/Unit category	
<input type="checkbox"/> <input type="checkbox"/>	No Entry
<input type="checkbox"/> > <input type="checkbox"/> 01	Upstream (E & P)
<input type="checkbox"/> > <input type="checkbox"/> 02	Midstream
<input type="checkbox"/> > <input type="checkbox"/> 03	Downstream
<input type="checkbox"/> > <input type="checkbox"/> 04	Petrochemical
<input type="checkbox"/> <input type="checkbox"/> 05	Water
<input type="checkbox"/> <input type="checkbox"/> 06	Renewable energy
<input type="checkbox"/> <input checked="" type="checkbox"/> 07	Fertilizer
<input type="checkbox"/> <input checked="" type="checkbox"/> 07.01	Potash
<input type="checkbox"/> <input type="checkbox"/> 07.01.01	Mining and extraction
<input type="checkbox"/> <input checked="" type="checkbox"/> 07.01.02	Processing plant

Value set adapted from ISO 14224:2016, Table A.1



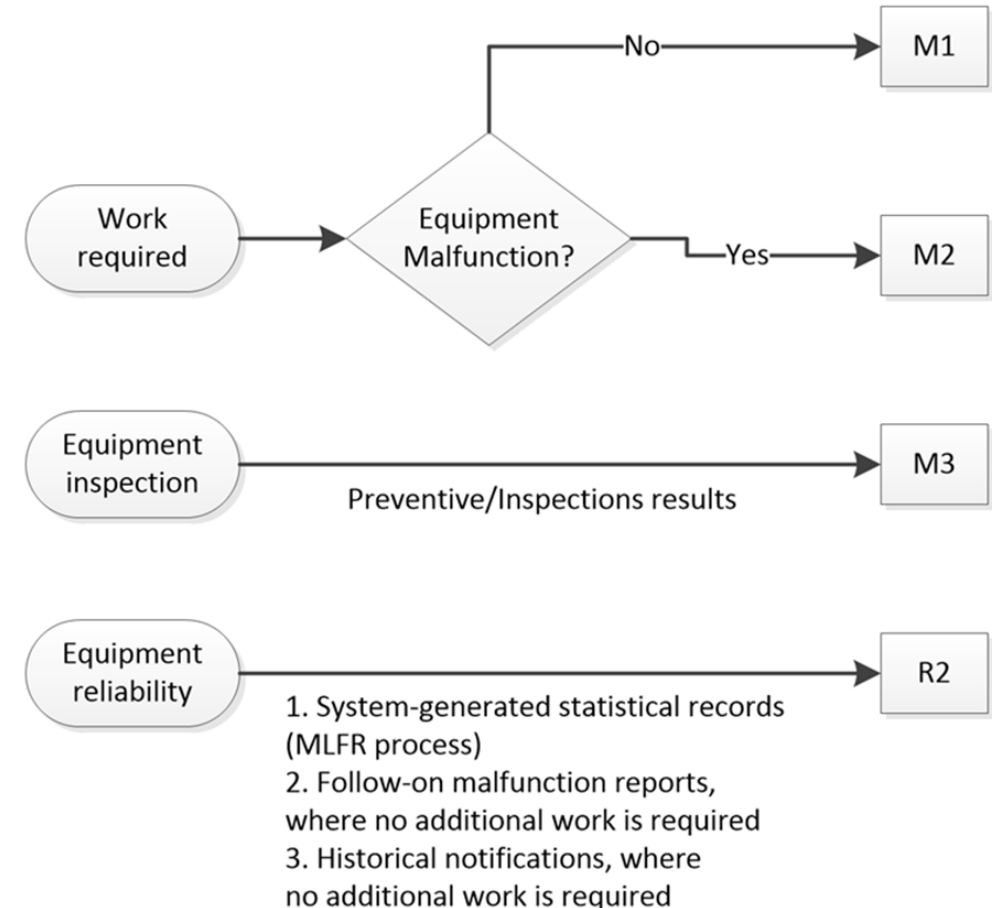
# ISPM Transactional Data Overview



# Maintenance Categorization

## Aligned with Data Requirements

- Three distinct categories and datasets
  - M1 – Maintenance Request
  - M2 – Failure/Malfunction Report
  - M3 – Prev. Condition Report
- Each has different data requirements
  - Separation is important for data relevancy
  - Only relevant fields can be validated
  - Reference ISO 14224:2016, Figure 6





# Maintenance Request

- Any non-malfunction request
- Coding is used to differentiate between work types
- Can be linked to other work by notification hierarchy

**Maintenance notification**

**Create PM Notification: Maintenance Request**

Notification: %0000000001 M1 Create PM for vibr. insp. - compactors

Status: OSNO APRQ

Order:

**Request** Documents

**Reference object**

Functional loc. 4013.11.24 COMPACTION

Equipment

Assembly

**Start/End Dates**

Required Start 2021.07.13 16:12:22 Priority 2-High

Required End 2021.07.14 16:12:22

**Subject**

Coding M1000100 1.8 Preventive Maint/Inspection Request

Description Create PM for vibr. insp. - compactors

2021.07.12 16:21:28 Tony Ciliberti (TCILIBER)  
Need monthly vibration checks for rotating items (motors and  
please.

**Responsibilities**

Planner group 010 / USRD Maintenance

Main WorkCtr GENTRADE / USRD General trades

Reported by TCILIBER Notif.date 2021.07.12 16:09:57

**Message text**

Notification priority is required.  
Maintenance request coding is required.  
Notification short text is required.

**Catalog Selection**

Coding

M1000100 Maintenance request coding

1.1 General work (non-malfunction)

1.2 Procedure create/change request

1.3 Manuf. service bulletin

1.4 Spill containment/clean-up

1.5 Facilities change request

1.6 Master data update

1.7 Technical services request

1.8 Preventive Maint/Inspection Request

9.9 Other (specify in text)

Choose



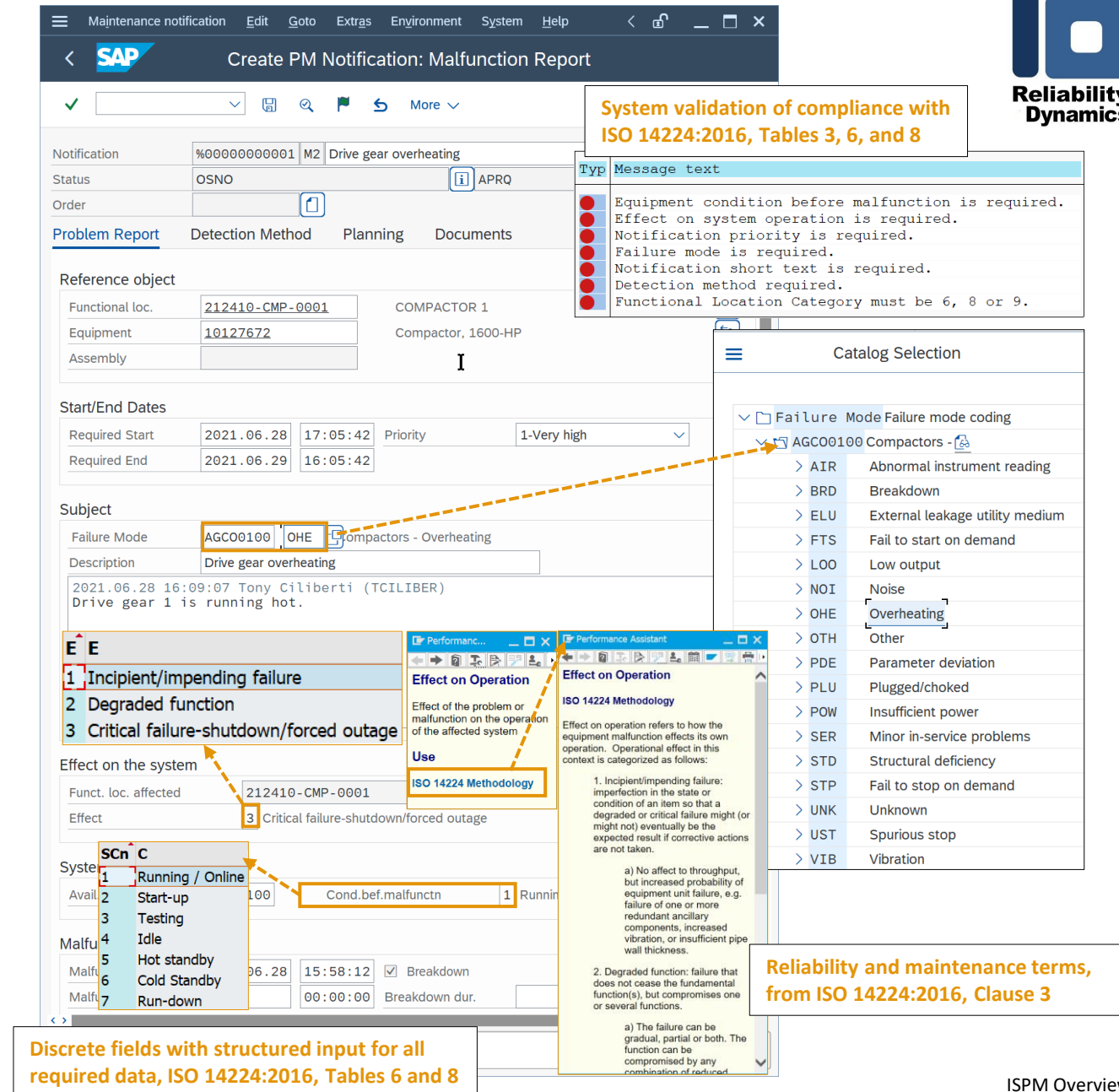
# Malfunction Report

## Work Initiation

- Logical work categorization, with one input form per category<sup>1</sup>
- Specifications of required data per work category<sup>2,3,4</sup>
- Discrete fields with structured input for each required datum
- System-validations to ensure compliance with specifications

### Notes - ISO 14224:2016

1. Figure 6 – Maintenance categories
2. Table 6 – Failure data
3. Table 8 – Maintenance data
4. Table 3 – Reliability and maintenance parameters in relation to taxonomy levels



**System validation of compliance with ISO 14224:2016, Tables 3, 6, and 8**

**Message text**

- Equipment condition before malfunction is required.
- Effect on system operation is required.
- Notification priority is required.
- Failure mode is required.
- Notification short text is required.
- Detection method required.
- Functional Location Category must be 6, 8 or 9.

**Catalog Selection**

- Failure Mode Failure mode coding
  - AGC00100 Compactors - [Failure mode coding]
  - AIR Abnormal instrument reading
  - BRD Breakdown
  - ELU External leakage utility medium
  - FTS Fail to start on demand
  - LOO Low output
  - NOI Noise
  - OHE [Overheating]
  - OTH Other
  - PDE Parameter deviation
  - PLU Plugged/choked
  - POW Insufficient power
  - SER Minor in-service problems
  - STD Structural deficiency
  - STP Fail to stop on demand
  - UNK Unknown
  - UST Spurious stop
  - VIB Vibration

**Performance Assistant: Effect on Operation**

**ISO 14224 Methodology**

Effect on operation refers to how the equipment malfunction effects its own operation. Operational effect in this context is categorized as follows:

1. Incipient/impending failure: imperfection in the state or condition of an item so that a degraded or critical failure might (or might not) eventually be the expected result if corrective actions are not taken.
2. Degraded function: failure that does not cease the fundamental function(s), but compromises one or several functions.
3. Critical failure-shutdown/forced outage: failure that causes a complete shutdown of the equipment or a forced outage.

**Discrete fields with structured input for all required data, ISO 14224:2016, Tables 6 and 8**

**Reliability and maintenance terms, from ISO 14224:2016, Clause 3**



# Malfunction Report

## Work Close-out

Validations check compliancy with ISO 14224:2016, Tables 6 and 8, on notification completion

Notification
10001386
M2
Drive gear overheating

Status
NOPR
APPR

Order

Problem Report
Repair Report
Activities
Planning
Documents

Maintainable Items
Failure Cause
Activities

No.	Code group	Mai...	Maint Items	Code group	Fail...	Failure Mech	Text	It...	Assembly	Assembly Descriptn
1	AGCO0200	0200	Main drive unit - Gearbox	FM000200	2.5	Material failure - Breakage	Bearing failure	21		BEARING, RADIAL

Maint Items
Maintainable item coding

AGCO0100 Feed unit -

AGCO0200 Main drive unit -

0001 No detail

0100 Motor

0200 Gearbox

0300 Motor base

0400 Shaft guard

0500 Footing/Mounting

AGCO0300 Compactor unit -

AGCO0400 Control and monitoring -

AGCO0500 Lubrication system -

AGCO9900 Miscellaneous -

Failure Mech
Failure mechanism coding

FM000100 Mechanical failure -

FM000200 Material failure -

2.0 General

2.1 Cavitation

2.2 Corrosion

2.3 Erosion

2.4 Wear

2.5 Breakage

2.6 Fatigue

2.7 Overheating

2.8 Burst

FM000300 Instrument failure -

FM000400 Electrical failure -

FM000500 External influence -

FM000600 Miscellaneous -

M2 Notification 10001386: Display messages

Type
Message text

Malfunction end date required.
Failure mechanism is required.
Maintainable item is required.
Corrective maintenance activity is required.
Failure cause code is required.

Display Long Text

- 1 -

MATERIAL FAILURE

2.0 GENERAL: a failure related to a material defect, but no further details known.

2.1 CAVITATION: relevant for equipment such as pumps and valves.

2.2 CORROSION: all types of corrosion, both wet (electrochemical) and dry (chemical)

2.3 EROSION: erosive wear

2.4 WEAR: abrasive and adhesive wear, e.g. scoring, galling, scuffing, fretting.

2.5 BREAKAGE: fracture, breach, crack

2.6 FATIGUE: if the cause of breakage can be traced to fatigue, this code should be used.

2.7 OVERHEATING: material damage due to overheating/burning.

2.8 BURST: item burst, blown, exploded, imploded, etc.



# Malfunction Report

## Consequence Classification

Object

Notification	10001386	Item number	1	Bearing failure
Class Type	015	Message item		

Values for Class PE\_ME\_CP - Object 10001386 0001

General Risk Customer

Characteristic Description	Value
<input type="checkbox"/> Failure Consequences	Production loss < US\$1MM
<input type="checkbox"/> Equipment/Area affected	4013
<input type="checkbox"/> Facility downtime	36 hrs

Value Hierarchy for Char. Failur...

	Desc.
<input type="checkbox"/> <input checked="" type="checkbox"/> Failure Consequences	
<input type="checkbox"/> > <input type="checkbox"/> E	Environment
<input type="checkbox"/> > <input type="checkbox"/> O	Operations
<input type="checkbox"/> <input checked="" type="checkbox"/> P	Production
<input type="checkbox"/> > <input type="checkbox"/> P1	Production catastrophic
<input type="checkbox"/> <input checked="" type="checkbox"/> P2	Production severe
<input type="checkbox"/> <input checked="" type="checkbox"/> P21	Production loss < US\$1MM
<input type="checkbox"/> > <input type="checkbox"/> P3	Production moderate
<input type="checkbox"/> > <input type="checkbox"/> P4	Production minimal
<input type="checkbox"/> > <input type="checkbox"/> P5	Production negligible
<input type="checkbox"/> > <input type="checkbox"/> S	Safety

ISO 14224:2016, Table C.2 – Failure consequence classification

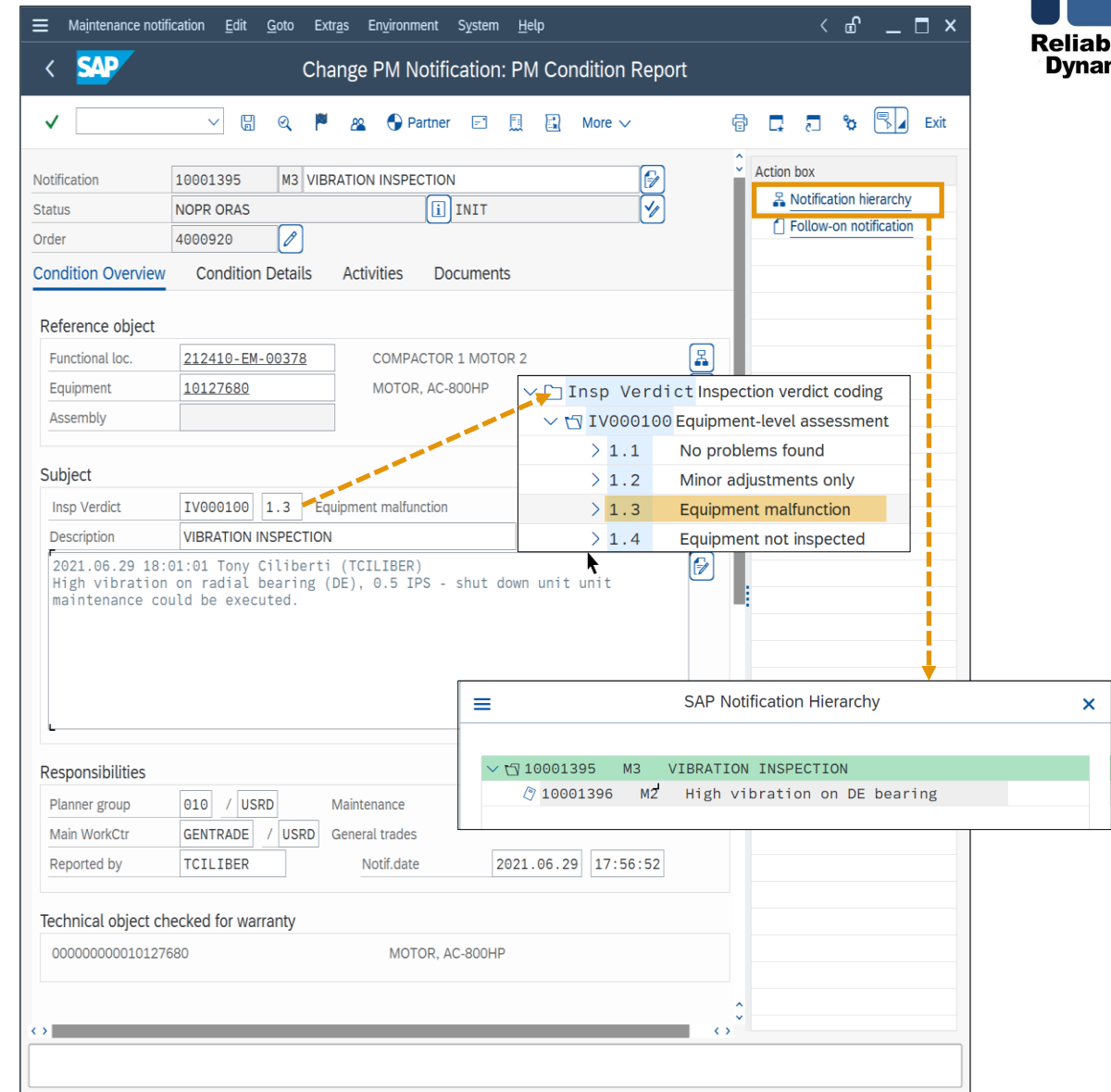
Consequences	Category			
	Catastrophic Failure that results in death or system loss	Severe Severe injury, illness or major system damage	Moderate Minor injury, illness or system damage	Minor Less than minor injury, illness or system damage
<b>Safety</b>	<b>I</b> — Loss of lives — Vital safety-critical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



# PM Condition Report

## Preventive Maintenance Results Recording

- One PM Condition Report per technical tag inspected, to record:
  - Inspection verdict
  - Condition details
  - Measurements taken
- Inspections linked to follow-on work by use of notification hierarchy
  - Follow-on notification generation is automated by the system
  - Notification hierarchy can be displayed and edited



The screenshot displays the SAP 'Change PM Notification: PM Condition Report' interface. The main form includes fields for Notification (10001395), Status (NOPR ORAS), and Order (4000920). The 'Condition Overview' tab is active, showing 'Reference object' (Functional loc. 212410-EM-00378, Equipment 10127680) and 'Subject' (Insp Verdict IV000100, Description VIBRATION INSPECTION). A dropdown menu for 'Insp Verdict' is open, showing options: 1.1 No problems found, 1.2 Minor adjustments only, 1.3 Equipment malfunction (selected), and 1.4 Equipment not inspected. A dashed orange arrow points from the selected verdict to the 'SAP Notification Hierarchy' pop-up window. This window shows a hierarchy starting with 10001395 M3 VIBRATION INSPECTION, followed by 10001396 M2 High vibration on DE bearing. The 'Responsibilities' section lists Planner group 010 / USRD, Main WorkCtr GENTRADE / USRD, and Reported by TCILIBER. The 'Technical object checked for warranty' is 000000000010127680 MOTOR, AC-800HP. The date and time are 2021.06.29 17:56:52.