Table C.4 – Example of consequence classes for spare parts

Consequence	Description
High	Equipment of a system that shall operate in order to maintain operational capability in terms of safety, environment and production.
Medium	Equipment of a system that have installed redundancy, of which either the system or its installed spare must operate in order to maintain operational capability in terms of safety, environment and production.
Low	No consequence for safety, production or environment.

Table C.5 – Example of risk matrix for spare parts

Consequence / Demand rate	Low	Medium	High
First line spare parts, frequently used.	Minimum stock at site	Minimum stock at site and any additional spare parts at central warehouse	Adequate stock at site
Not frequently used.	No stock	Central warehouse, no stock at site	Central warehouse and minimum stock at site if convenient
Capital spare parts. Seldom or never used.	No stock	No stock	Holding optimized by use of risk assessment case by case

Annex D
(informative)
Practical examples

D.1 Technical hierarchy

The level of detail with regards to tagging is in many ways a deciding factor to ensure that the equipment will receive the adequate maintenance. On the Norwegian Continental Shelf there is an industrial heritage of tagging to a detailed level where even instrumentation and equipment in support of MFs and sub functions are tagged The tagging is to be consistent from drawings, the actual equipment in the installation and the CMMS and is an important part of documenting the equipment through its life cycle.

Figure D.1 illustrates the workflow to establish a technical hierarchy.

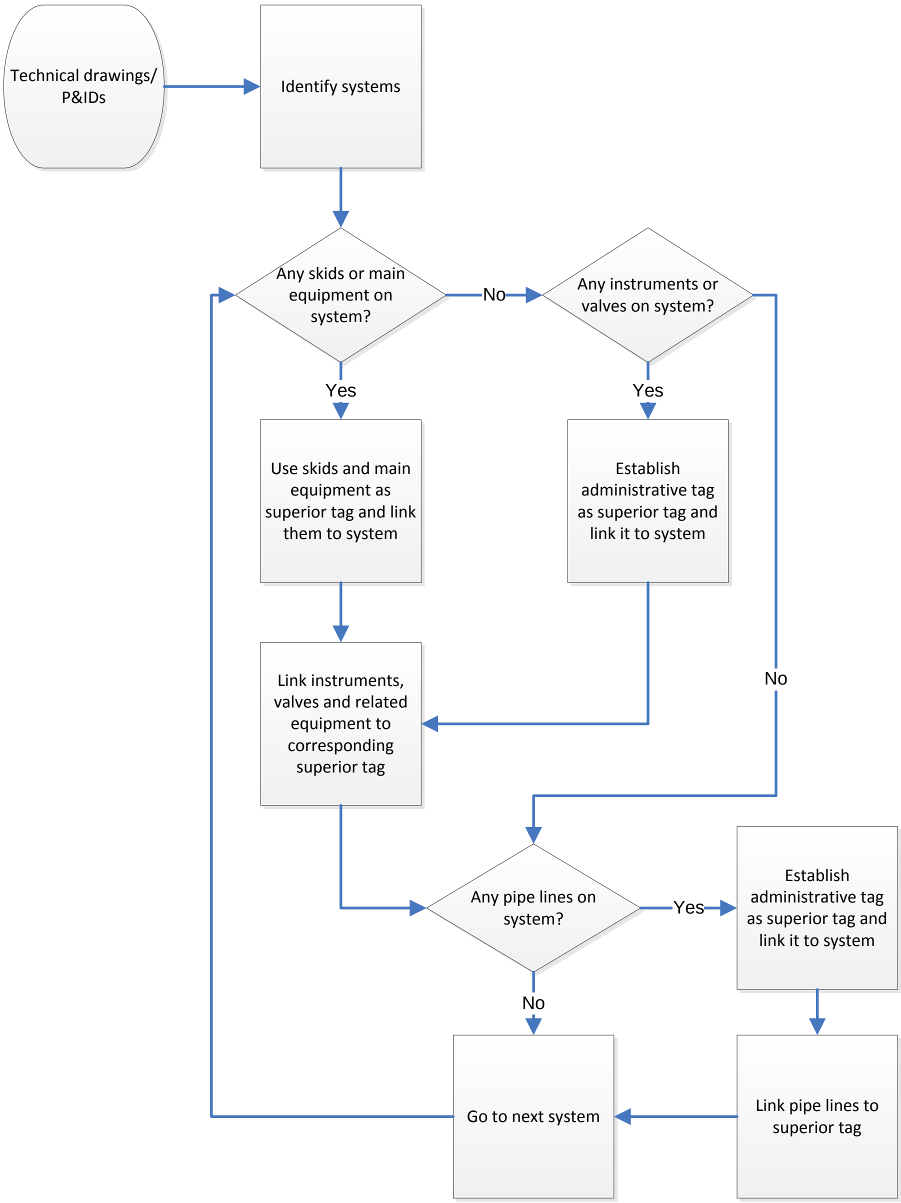

Figure D.1 – Work process technical hierarchy

To establish a technical hierarchy it is necessary with a set of technical drawings, e.g. flow and one-line diagrams, P&IDs etc. and a list of tags and a tool for linking tags to each other.

The top of the technical hierarchy normally starts with the installation code with the system numbers listed in Figure D.2. The usage of system numbers may vary from plant to plant NORSOK Z-DP-002 uses system numbers between 00 and 99. Other standards like SFI [Ship research institute of Norway (Skipsteknisk Forskningsinstitutt)] would have a 3 digit numbers as system numbering, but the principles may be similar.

Technical drawings can be used to identify skids, packages and main equipment that can work as a superior tag for the connected instruments, valves and other kinds of equipment. There can be several levels beneath a level, e.g. a skid that contains 2 pumps with electric motors. The skid will then be the top level, the pumps will be the 2nd level, and the electric motors will be the 3rd level to the corresponding pump. Each level can hold corresponding instruments and valves. See Figure D.2.

Start with a system by identifying skids and main equipment. Then link all the skids and main equipment that will be used as a superior tag to the system number in the tree structure. Next step is to identify the instruments, valves and other kinds of equipment on the system and connect them to the corresponding skid or main equipment. If there are no skids or main equipment, but only e.g. instruments or valves, then administrative tags should be established to form the level above. The instruments, valves and other kinds of equipment are then linked to the administrative tags. In instrument loops one of the components can represent the whole loop e.g. a transmitter or valve, while the rest of the loop lie beneath.

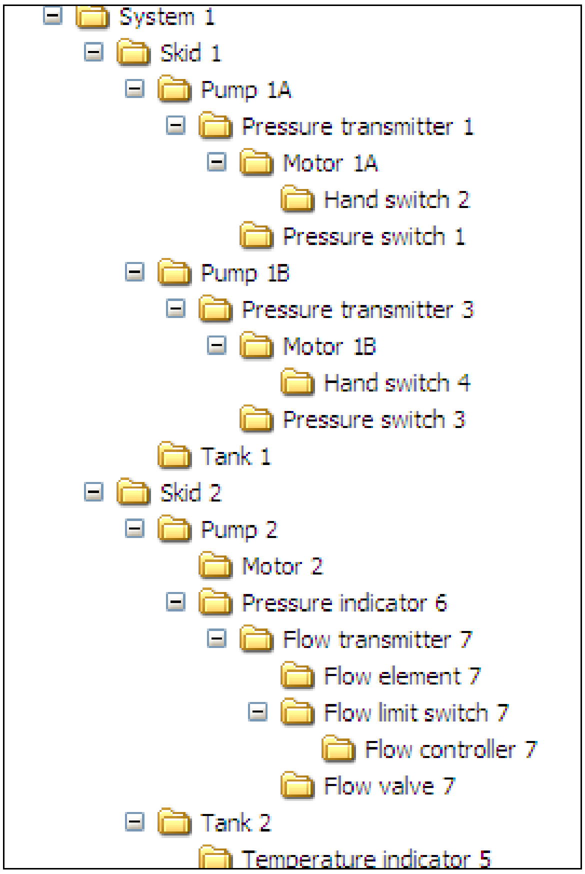

Figure D.2 – Technical hierarchy

D.2 Functional hierarchy

The functional hierarchy is a logical diagram linking all the plant functions noted as MF and sub functions, see Annex A. The level of detailing of the functional hierarchy may vary, but usually 2 to 3 levels are sufficient.

The plant system 27 (gas export) is shown in Figure D.3 in a schematic diagram of a plant (platform) which has been broken down into equipment identified by its tag number. The defined MFs covering part of this system and the standardised sub functions for one of these MFs are illustrated as an example.

Each tag within one sub function is given the same classification because a fault on any of these units (identified by the tag numbers) will cause the same consequence on the MF.

D.3 Documentation of consequence analysis

A typical example of a consequence analysis of a MF (2701 Scrubbing), with standard sub functions listed, is shown in Figure D.4. This MF consists of two parallel units, each able to perform 100 % of the scrubbing function in relevant operating mode. Although this example identifies 100 % redundancy for this MF, redundancy is ignored at this time. For the purpose of determining the consequence class all MFs should be considered as single, irrespective of their design redundancy. A fault which prevents the MF from operating will affect the system (Gas export) immediately (within ‘0’ hours) with a 100 % loss of functionality. This time is called ’Critical time in the list of sub functions. The consequence classification is 3 (high), 2 (medium) and 1 (low). The degree of redundancy is set by characters A, B or C for the relevant operating mode. The degree of redundancy for sub-functions is set based on number of PUs and capacity (Cap: 50 %, 100 %).

Explanation: Cons = Consequence. Figures: 3=High, 2=Medium, 1=Low HSE, Production and Cost respectively. Last result is a combination of the highest Consequence and Redundancy degree (A – No spare, B – One spare, C – Two or more spares) in operational phase.

Figure D.3 – Functional hierarchy, example with standard sub function and classification

Z-008	CONSEQUENCE OF MAIN FUNCTIONS AND ITS FUNCTIONS

System 27. GAS EXPORT AND METERING

Main Function: 2701	**SCRUBBING**		Parallel Unit 2	Capacity per unit: 100	Redundant grade B
Documents	Doc A: C-F027-P-*P-002-01	Doc. B: C-F027-P-*E-001\004-01	PID: C025-C-FO27-P-*E-001-01	Rev: B	Last updated: 21.02.00

Critical failure which affects system in 0 hours with 100 % reduction			Classification			
Failure mode	System effect:	Installation effect	S	P	O	H
Does not work	System in shut down/is not available. Max. 4 hours (valve/instrument failure).	Gas production is shut down and flared. CO_2 tax (100.000 – 1 mill. NOK), and environment consequence. Oil production to be maintained according to tariff quotas.	2	3	2	N
Works improperly	Reduced condensate separation	No immediate effect	1	1	1	N

Function	**Description**	Reduction	Crit. time	PU*Cap>Re	Does not work	Works improperly	Classification
2701 MAIN	Scrubbing	100 %	0	2*100>B	232-N	111-N	232>3
2701 ALARM	Monitoring	0 %	168	2*100>B	211-Y	111-N	211>2
2701 CONTRO	Controlling	100 %	0	2*100>B	232-N	111-Y	232>3
2701 IND	Local indication	0 %	720	2*100>B	111-N	111-Y	111>1
2701 PSD	Shutdown, Process	100 %	0	2*100>A	333-Y	111-N	333>3
2701 EQSD	Shutdown, Equipment	100 %	0	2*100>A	212-Y	111-N	212>2
2701 PSV	Pressure relief	100 %	0	2*100>A	333-Y	111-N	333>3
2701 VALVE	Manual shut-off	100 %	0	2*100>B	232-N	-	232>3
2701 PV	Containment, Process Vapour	100 %	0	2*100>A	333-N	-	333>3

Table key

Classification (S: Safety; P: Production; O: Other)
3: High
2: Medium
1: Low
Hidden failure (H)
Y: Yes
N: No

Figure D.4 – Consequence assessment of a MF. The example is shown with some key data and the classification of the sub functions listed below

D.4 Documentation of generic maintenance concept (GMC)

A GMC is a set of maintenance actions, strategies and maintenance details, which can be seen as a collection of best practices for a company. The GMC should be defined by a structured RCM analysis where failure modes and failure causes are identified.

All tags should be linked to a relevant GMC and should be available for reference directly in the CMMS. Use of dummy concepts should be restricted to a minimum and only linked to tags where a detailed generic maintenance analysis has revealed no need for any maintenance activity. Equipment which is part of an instrument loop, but no concept is applicable, should be linked to same concept as the superior tag, i.e. instrumented valve.

Each concept shall specify which type of equipment the concept is covering and which type of equipment that is excluded. Each concept should be detailed at such level that it provides sufficient information, as keywords or by a short description, about relevant maintenance activities and intervals of such activities in order to maintain the equipments intended function. It should be avoided to specify maintenance activity at the concept which is not relevant for the actual functional location which the concept are linked to.

The table below shows the final result and not the documentation of the entire process.

Generic maintenance concept

Equipment class:	*Pump*
Equipment type:	*Centrifugal*
Dominating failure mode	*Spurious stop*
Operating and frame conditions for concept:	*25-500 KW*
Responsible:	*Mechanical static equipment leader*
Revision:	*Rev1, 22.09.2009*
Comments:	

Sub unit	Activity	Activity description	Ref. to maint.doc.	Discipline	Req. from Gov/Comp?	Shu own?	Generic Interval	
Pump unit	Visual check	Brief routine check for leak, dirt, noise, vibration	xx-yy-zz	Oper.	N	N	1	1
Control and monitoring	Monitoring	Evaluate vibration data	xx-yy-zz	Mech.	N	N	6	6
Lubrication system	Replace	Replace oil	xx-yy-zz	Mech.	N	Y	6	12
Etc.								

D) Discipline
M) Requirement from Government/Company
N) Shutdown required to undertake repair, and possibly production shutdown depending on redundancy and HSE requirements

Equipment class	ISO 14224 provides a recommended structure for equipment class
Equipment type	ISO 14224 provides a recommended structure for equipment type
Dominating failure mode	The dominating failure mode used in the maintenance analysis. ISO 14224 provides recommended failure modes.
Operating and frame conditions	Physical operating and frame conditions for the concept
Responsible	Responsible person/discipline for this concept
Revision	Revision number

Sub unit	ISO 14224 provides a recommended structure for sub unit
Consequence class	Consequence class for maintainable item from consequence classification
Redundancy Activity	Redundancy for maintainable item from consequence classification Preventive maintenance activities
Activity description	Description of PM activities
Ref to main doc	Reference to detailed description of maintenance activity
D) Discipline	Craft/competence (e.g. Mech: mechanic, El: electric, Oper: operator)
M) Requirement from government/company	Regulations and company requirements. For safety functions:
	Safety critical failure with connected testing interval SIL requirement (acceptance level)
N) Shutdown required	Need for equipment shutdown
Generic Interval	Generic maintenance interval established based on consequence classification, operating conditions etc.
Interval unit	Months, years, hours etc.