The Complete Guide to

Bill of Material (BOM) for Excellence In Facility Operation and Maintenance

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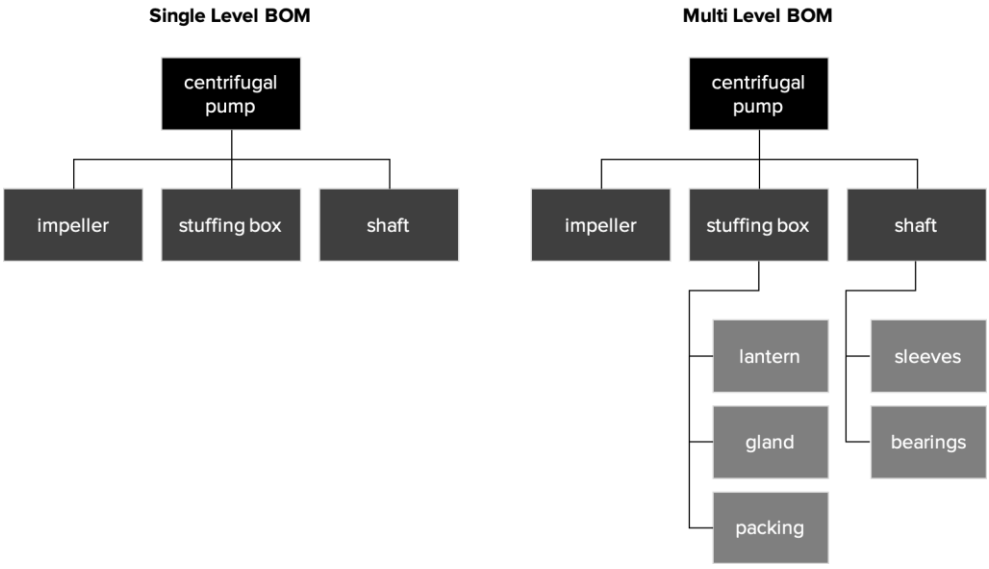
The Complete Guide to Bills of Materials (BOM) for Excellence in Facility Operations and Maintenance

Bills of Materials (BOMs) are a key element in describing the configuration of a facility. They are a pivotal input for spares optimization, procurement planning and urgent maintenance requirements. It's especially true for complex facilities such as offshore platforms, refineries, and chemical plants. Yet, BOMs are often inadequately developed, limiting their potential contribution to achieving operational excellence.

This pillar page is your gateway to understanding, developing, and using BOMs in complex facilities. It describes BOM types, use cases, and taking advantage of artificial intelligence for BOM creation.

What is a BOM?

A BOM shows the configuration of a physical asset to some level of detail. A Single-Level BOM shows the configuration one level down, while a Multi-Level BOM shows a comprehensive breakdown of the configuration.



Most online articles and software solutions describe BOMs from the perspective of a *product seller*:

- Engineering BOM (EBOM) lists assemblies, components, and parts to build a product. It also usually includes reference standards and specifications.
- Manufacturing BOM (MBOM) adds information such as processing steps, required machinery, and packaging requirements to the EBOM.
- Sales BOM (SBOM) shows feature and configuration options available to customers.
- Kit BOM is used in situations where products are sold in packages, and lists the items included in a package.

A facility operator, on the other hand, is a *product user*. The only relevant BOMs in this context are Service BOMs that list the serviceable items of a product. For example, the MBOM for a junction box may show the breakdown of a circuit board to the level of capacitors, diodes, and resistors, but the corresponding Service BOM may stop at the level of the circuit board because that's the lowest serviceable item onsite.

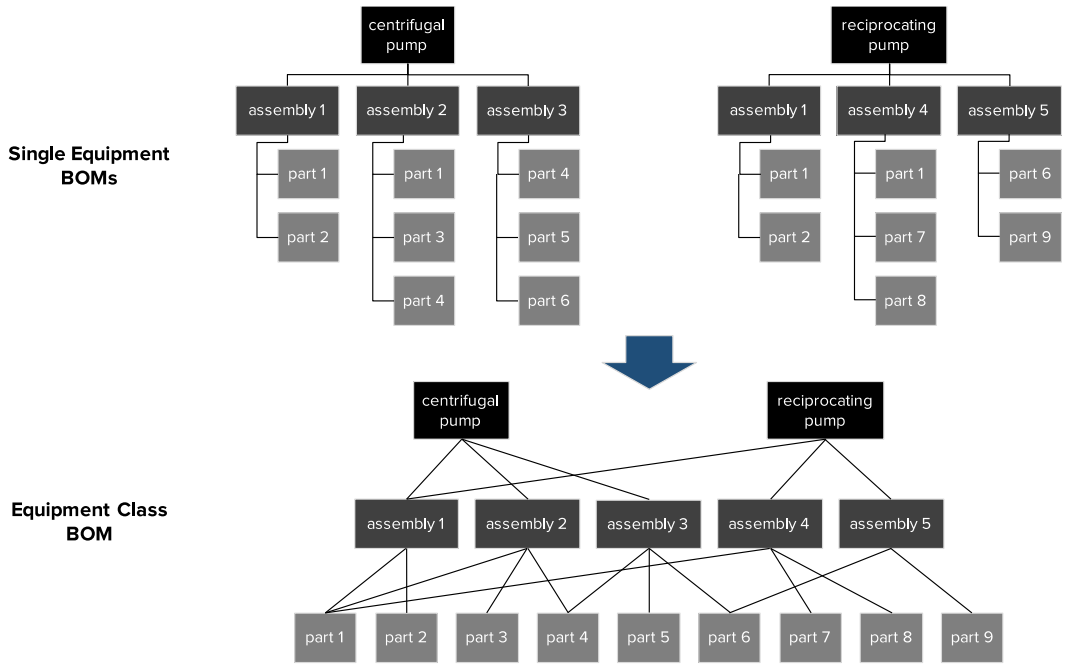
Service BOMs may be developed for:

- Preventive Maintenance comprising a standard list of parts, consumables, and tools required for servicing a single equipment
- Turnarounds comprising custom list of anticipated parts, consumables, and tools for servicing and fixing a spectrum of equipment
- Corrective Maintenance comprising a custom list of anticipated parts, consumables, and tools required for fixing an equipment

The Concept of Equipment Class BOMs for Facility O&M

Conventional BOMs are for a single product, which is adequate for preventive maintenance, but less so for spares optimization, procurement planning and urgent maintenance requirements. Let's look at why.

All manufacturers standardize parts across their products in the same class to save on manufacturing cost. For example, the drive shaft used in centrifugal pumps, reciprocating pumps, and other pumps within a specification range may be identical. Different manufacturers may procure the same parts from a supplier, but code them differently. There may also be parts in equipment that have been purchased directly a supplier that sells parts that are functionally equivalent to the original—these will be coded differently. An Equipment Class BOM unifies the "forest" of single equipment BOM trees across an equipment class. Such a BOM is key input for spares optimization, procurement planning and urgent maintenance requirements.



The Equipment Class BOM above is a simplified view of a graph (alternatively network or lattice) structure showing the interconnectivity of equipment, assemblies, and parts across an equipment class (pumps in this case). The weights associated with the links (not shown for simplicity) may be assembled quantities, maintained quantities, and so forth. If the Equipment Class BOM is constructed in a graph database, it's possible to apply graph data science techniques to identify groups of identical or similar parts; their significance to the operation; and paths across the equipment class. We will see in the next section how these techniques can save millions of dollars in inventory and lost time waiting for urgently needed parts.

Leveraging BOMs for Enhanced Facility Maintenance

BOMs are pivotal for effective facility operation and maintenance. Let's explore how you can harness BOMs for this purpose.

Spares Optimization

Facility operators seek to maintain a level of spares that balances the risk of lost revenue from equipment downtime against the risk of locking cash in excess safety stock. It's mathematically established that aggregating demand can reduce the quantity of safety stock without increasing downtime risk.

If you have Equipment Class BOMs linking functionally similar parts, irrespective of how they were coded in engineering documents, you can use them to aggregate demand for parts accurately. The quantities associated with parts for this purpose will be the maintained quantities and not the

assembled quantities. Ideally, it should include correlating factors. For example, a change of lubricating oil type may positively or negatively impact the demand for multiple parts.

Procurement Planning

BOMs should contain information such as original and alternate suppliers for parts, delivery lead times, prices, warranties, and carbon footprints. This information facilitates efficient and economical procurement.

Note: Some companies record this information in a material catalog.

Urgent Needs in Turnarounds and Corrective Maintenance

Regardless of how well planned turnarounds are, it's almost certain that unexpected requirements for parts will occur. Time is of the essence when an unexpected requirement occurs, and Equipment Class BOMs can address this by identifying substitute parts in non-critical equipment. For example, if the rotor assembly in a pump is unexpectedly damaged, you could identify a replacement in a non-critical equipment through an Equipment Class BOM for pumps.

The same applies to urgent needs in corrective maintenance.

Preventive Maintenance Planning

Preventive Maintenance (PM) is an instrumental component of any robust maintenance plan. Comprehensive BOMs allow maintenance planners to ensure that the required parts, consumables, and tools are specified for PM.

Challenges and Solutions in Developing BOMs

While BOMs are an essential tool in various industries, they are not always readily available or developed for facility maintenance and management. Several factors can contribute to this. Let's explore some common challenges and the solutions to overcome them.

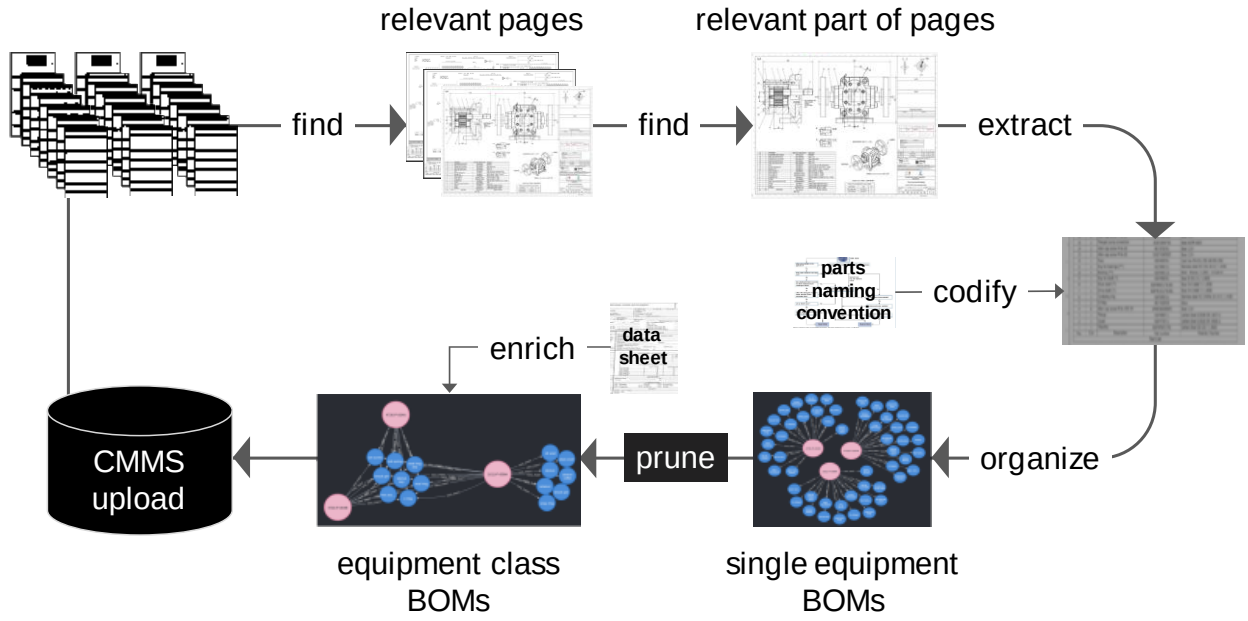
Missing Data

One significant hurdle in developing BOMs is the absence of comprehensive data. This could happen because the reference documents were incompletely transferred by the EPC contractor or original owner in a facility transaction. Or, perhaps documents transferred in paper form deteriorated, or modifications went unrecorded.

The typical solution is to request the missing data from the manufacturer or procure what's available from a generic product cataloger. These are the only options available to a company operating a limited number of facilities. For a company operating many facilities, it's possible that data missing in one facility is available at another facility. If you cross reference all data across the company's portfolio of facilities, you may be able to fill in some data gaps. This is only feasible through artificial intelligence (AI) and graph technologies.

Legacy Data and Manual Processes

This is a typical BOM–material catalog workflow.



Some facilities still have legacy data in paper or scanned documents. Manually finding BOM relevant data dispersed across thousands, even millions, of pages in such documents, and then transferring them into a machine readable form such as Excel for all the steps in the workflow, is time and cost prohibitive. It's also error prone, because many tasks are typically assigned to humans without engineering knowledge.

Typically, operators solve this by developing a limited set of "operational" BOMs from SPIRs (Spare Part Interchangeability Records) transferred by the EPC contractor. The problem is these SPIRs are usually only available for some equipment, and only show parts that need to be changed in the early part of that equipment's life cycle. The ideal solution is to build "assembly" BOMs providing detailed information about the configuration of equipment. Again, this is only feasible using AI technologies. Graph technologies aren't needed for developing Single Equipment BOMs, but are necessary for developing Equipment Class BOMs.

Lack of Awareness

While facility operators should be aware of the value of Single Equipment BOMs, they are less likely to know the value of Equipment Class BOMs because it's a concept that's principally used in a manufacturing context. Operators need to be aware that developing comprehensive BOMs requires integrated knowledge of and capabilities working with engineering data, mathematics of supply chain, and AI–graph technologies. They don't need to know how these technologies work in detail, but do need to know how they add value for achieving operational objectives.

Resource Constraints

All companies have resource constraints. This is a key area where AI and graphs can bring significant value since they provide far more for far less than conventional BOM development processes.

The Relevant AI and Graph Technologies for Developing BOMs

AI and graph technologies developed for specific domains and their sub-disciplines can deliver performance that is superior to generic solutions.

Optical Character Recognition (OCR)

Optical Character Recognition (OCR) technology is an enabling technology for developing BOMs. OCR can convert scanned, and even handwritten, documents into machine-readable text. This is a prerequisite for the application of all subsequent AI–graph technologies.

That being said, it's important that you only use OCR where it is needed because all OCR software may introduce errors. For example, OCR software may think a "B" is an "8", so, it's important to identify pages that are machine readable, and not send them for OCR. This will minimize errors, and save cost and time.

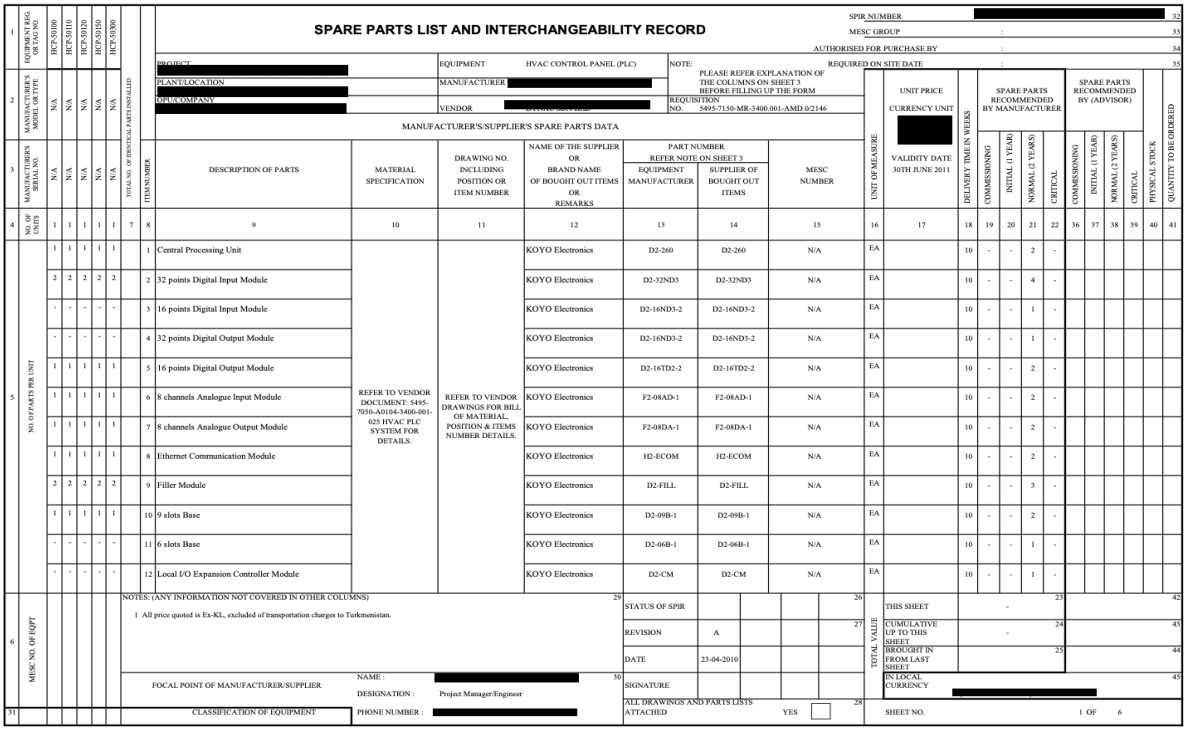
Page Classification

Manually searching through 10,000 page vendor books for cross sectional diagrams with parts lists is no fun. No more. A mix of computer vision and natural language understanding technologies, together with technical document axioms, can split up huge files, review page content, and highlight relevant pages in a fraction of the time. Software for developing BOMs should identify the following engineering pages.

- Cross-sectional diagrams
- General assembly drawings
- Parts lists
- SPIR
- Data sheets

Table Extraction

BOM-relevant data typically resides in tables in pages such as cross-sectional diagrams, parts lists and data sheets. Capturing this information is significantly faster thanks to advancements in table detection and extraction, especially if you need to extract complex tables such as those found in SPIR and data sheets.



SPARE PARTS LIST AND INTERCHANGEABILITY RECORD

SPIR NUMBER [redacted] 32
MESC GROUP : 33
AUTHORISED FOR PURCHASE BY : 34
REQUIRED ON SITE DATE : 35

PROJECT [redacted]
PLANT/LOCATION [redacted]
OPU/COMPANY [redacted]
EQUIPMENT HVAC CONTROL PANEL (PLC)
MANUFACTURER [redacted]
VENDOR [redacted]
NOTE: PLEASE REFER EXPLANATION OF THE COLUMNS ON SHEET 3 BEFORE FILLING UP THE FORM
REQUISITION NO. 5495-7150-MR-3400.001-AMD.0/2146

MANUFACTURER'S/SUPPLIER'S SPARE PARTS DATA

1 EQUIPMENT REG. OR TAG NO.		HCP-50100	HCP-50110	HCP-50120	HCP-50130	HCP-50200	TOTAL NO. OF IDENTICAL PARTS INSTALLED	ITEM NUMBER	DESCRIPTION OF PARTS	MATERIAL SPECIFICATION	DRAWING NO. INCLUDING POSITION OR ITEM NUMBER	NAME OF THE SUPPLIER OR BRAND NAME OF BOUGHT OUT ITEMS OR REMARKS	PART NUMBER REFER NOTE ON SHEET 3		MESC NUMBER	UNIT OF MEASURE	UNIT PRICE CURRENCY UNIT [redacted] VALIDITY DATE 30TH JUNE 2011	DELIVERY TIME IN WEEKS	SPARE PARTS RECOMMENDED BY MANUFACTURER			SPARE PARTS RECOMMENDED BY (ADVISOR)				QUANTITY TO BE ORDERED
													EQUIPMENT MANUFACTURER	SUPPLIER OF BOUGHT OUT ITEMS					COMMISSIONING	INITIAL (1 YEAR)	NORMAL (2 YEARS)	CRITICAL	COMMISSIONING	INITIAL (1 YEAR)	NORMAL (2 YEARS)	CRITICAL	PHYSICAL STOCK
2 MANUFACTURER'S MODEL OR TYPE		N/A	N/A	N/A	N/A	N/A																				
3 MANUFACTURER'S SERIAL NO.		N/A	N/A	N/A	N/A	N/A																				
4 NO. OF UNITS		1	1	1	1	1	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	36	37	38	39	40	41
5 NO. OF PARTS PER UNIT		1	1	1	1	1		1	Central Processing Unit	REFER TO VENDOR DOCUMENT: 5495-7050-A0104-3400-001-025 HVAC PLC SYSTEM FOR DETAILS.	REFER TO VENDOR DRAWINGS FOR BILL OF MATERIAL, POSITION & ITEMS NUMBER DETAILS.	KOYO Electronics	D2-260	D2-260	N/A	EA		10	-	-	2	-						
		2	2	2	2	2		2	32 points Digital Input Module			KOYO Electronics	D2-32ND3	D2-32ND3	N/A	EA		10	-	-	4	-						
		-	-	-	-	-		3	16 points Digital Input Module			KOYO Electronics	D2-16ND3-2	D2-16ND3-2	N/A	EA		10	-	-	1	-						
		-	-	-	-	-		4	32 points Digital Output Module			KOYO Electronics	D2-16ND3-2	D2-16ND3-2	N/A	EA		10	-	-	1	-						
		1	1	1	1	1		5	16 points Digital Output Module			KOYO Electronics	D2-16TD2-2	D2-16TD2-2	N/A	EA		10	-	-	2	-						
		1	1	1	1	1		6	8 channels Analogue Input Module			KOYO Electronics	F2-08AD-1	F2-08AD-1	N/A	EA		10	-	-	2	-						
		1	1	1	1	1		7	8 channels Analogue Output Module			KOYO Electronics	F2-08DA-1	F2-08DA-1	N/A	EA		10	-	-	2	-						
		1	1	1	1	1		8	Ethernet Communication Module			KOYO Electronics	H2-ECOM	H2-ECOM	N/A	EA		10	-	-	2	-						
		2	2	2	2	2		9	Filler Module			KOYO Electronics	D2-FILL	D2-FILL	N/A	EA		10	-	-	3	-						
		1	1	1	1	1		10	9 slots Base			KOYO Electronics	D2-09B-1	D2-09B-1	N/A	EA		10	-	-	2	-						
		-	-	-	-	-		11	6 slots Base			KOYO Electronics	D2-06B-1	D2-06B-1	N/A	EA		10	-	-	1	-						
		-	-	-	-	-		12	Local I/O Expansion Controller Module			KOYO Electronics	D2-CM	D2-CM	N/A	EA		10	-	-	1	-						
6 MESC NO. OF EQPT																										

NOTES: (ANY INFORMATION NOT COVERED IN OTHER COLUMNS) 29
1 All price quoted is Ex-KL, excluded of transportation charges to Turkmenistan.

STATUS OF SPIR				26
REVISION	A			27
DATE	23-04-2016			
SIGNATURE				30
ALL DRAWINGS AND PARTS LISTS ATTACHED	YES ☐			28

TOTAL VALUE
THIS SHEET - 23 42
CUMULATIVE UP TO THIS SHEET - 24 43
BROUGHT IN FROM LAST SHEET 25 44
IN LOCAL CURRENCY [redacted] 45

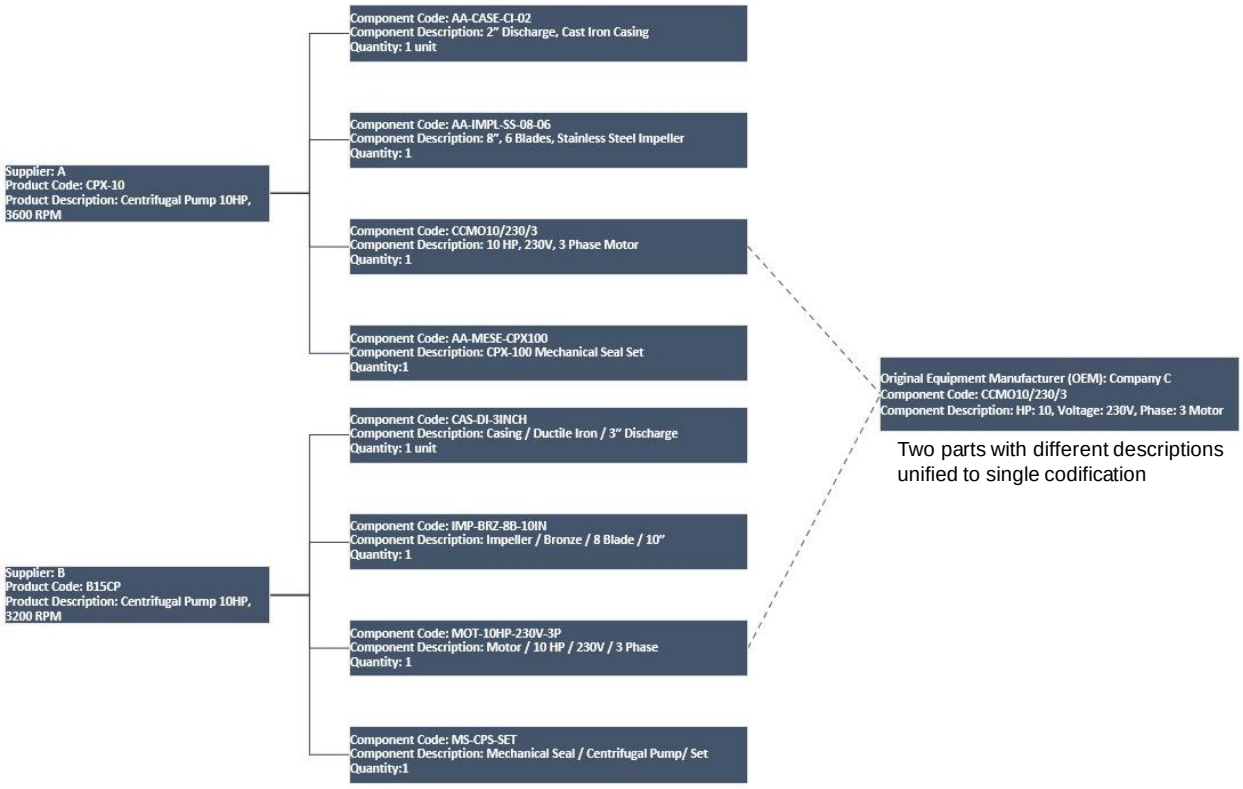
FOCAL POINT OF MANUFACTURER/SUPPLIER
NAME : [redacted]
DESIGNATION : Project Manager/Engineer
PHONE NUMBER : [redacted]

31 CLASSIFICATION OF EQUIPMENT

SHEET NO. 1 OF 6

Component Reconciliation

We've already discussed how Equipment Class BOMs unify Single Equipment BOMs by identifying and linking identical and similar components across an equipment class. This requires a combination of natural language understanding and graph technologies. The original and reconciled terms for a component would be stored in an Equipment Class BOM.



Two parts with different descriptions unified to single codification

Collaboration and Accessibility

You can import the organized BOM data into asset management software such as a CMMS or EAM for maintenance planning and procurement. You can also integrate BOMs into an Enterprise Knowledge Graph to link asset configuration data to sensor, database, and document data about the corresponding assets.

If remote access to the BOM data is set up using a cloud or other solution, and coupled with collaboration applications on computers and mobile devices, it's possible for dispersed stakeholders to seamlessly work together.

Developing your BOMs

Developing Single Equipment and Equipment Class BOMs at the assembly level is now faster and cheaper using AI–graph based software. If you decide Single Equipment BOMs are the way to go, your team can use Cekap's engineer-friendly software to develop them, or you can use us to do it. If, however, you decide to develop Equipment Class BOMs, then your team will need to have a graph engineer or you will need to outsource the development to us. Investing in developing Equipment Class BOMs can unlock significant savings on safety stock, procurement planning and increase ability to deal with unexpected developments in turnarounds and CMs.