

DATA MODELING FOR ENGINEERING CHANGE MANAGEMENT PROCESSES IN ENGINEERING INDUSTRIES

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ABSTRACT

Engineering Industries (EI), Product Lifecycle Management (PLM) and Engineering Change Management project with the objective of reengineering several business processes and enabling the processes within PLM^{4,5,6,8,11,13,16,19,22,24,27,30,35} applications and DMS^{21,28,34,36} applications. The Project covers Engineering Industries (EI) such as Energy Devices^{21,28,34,36}, Telecom devices, automotive global design centers and manufacturing facilities. The design approach will be covering the Engineering industry's single PLM^{4,5,6,8,11,13,16,19,22,24,27,30,35} system platform for entire Organization for design change.

Fundamental project management discipline and tools will be used to control, execute, and monitor the EI^{4,5,6,8,11,13,16,19,22,24,27,30,35} implementation. All Scope Change Requests will require cost justification and approval of the EI Steering Committee. A monthly Risk Management Report will summarize the risks, identify the mitigating measures necessary and identify respective responsibilities for implementing them.

EI's key objectives for this Project are:

- *Enable business process and engineering management efficiency through a single integrated global process model.*
- *Achieve the value for Business Value Assessment through below process:*
 - *Business Process Management (BPM)*
 - *Process transformation and integration*
 - *Standardization of business processes*
 - *Strong data governance*
 - *Increased automation of processes*
 - *Expanded process and business system capability*
- *Implement a Common Enterprise platform across EIs design centers in the Americas leading to accurate and timely Business information*
- *Leverage out-of-the-box functionality and minimize system customization*

Key words: Product Lifecycle Management (PLM), Product Data Management (PDM), Engineering Change Management (ECM), Energy Systems, System Admin, Information Systems, Information and Software Technology, Engineering, DMS.

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1. PROJECT REQUIREMENTS

Company needs engineering change proposal for all their products which has customer complaints and based on the customer complaint the product needs to be re-designed.

1.1. Objective

Propose PLM ^([4],[5],[6],[8],[11],[13],[16],[19],[21],[23],[26],[29],[33]) based system to track the engineering change requirement request and how the changes are analyzed and approved by the managers to proceed with the changes and their rollout.


1.2. Accomplishment

- Identify the project sponsors, stake holder and define the steering committee
- Successfully completed the Elicitation process.
- Understand the business requirement
- Develop the scope of the project
- Identify the GAP in the project
- Identify the software solution – Application fitment assessment
- Use case scenario
- Data flow diagram
- Project benefits and outcome analysis
- KPI's
- Energy Devices Processes 21,28,34,36,
- Engineering Industries
- Automotive

1.3. Project Kick-Off

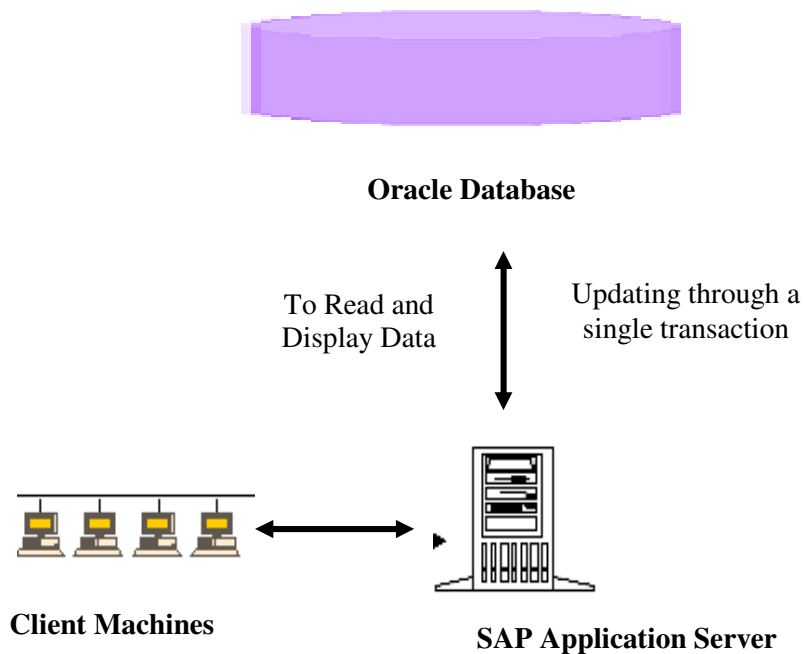
Our team who did system analysis and design project (Group 5) have regrouped again to start the database design project. We initiated a conference call to strategize the tasks and role to be played by each member of the team. Since this project is more functional driven, our SME for the project will be Ilayaraja Muthalagu and other members of the team will support the database design based on the agreement from entire team.

1.4. ECM Database Design Project Plan

	 Task Name	Duration	Start	Finish	Pred	Resource Names
1	Engineering Change Management Data Modeling Project	36 days?	Mon 10/28/13	Mon 12/16/13		
2	Database Project Preparation	8 days	Mon 10/28/13	Wed 11/6/13		
3	Define Database Design Requirements	8 days	Mon 10/28/13	Wed 11/6/13		Group - 5 Team
4	Data Modeling Blueprint	9 days?	Thu 11/7/13	Tue 11/19/13		
5	Data Modeling Design	3 days	Thu 11/7/13	Mon 11/11/13	3	Group - 5 Team
6	Performance Design	1 day?	Thu 11/14/13	Thu 11/14/13	5	Group - 5 Team
7	Normalization	1 day?	Tue 11/19/13	Tue 11/19/13	6	Group - 5 Team
8	Data Modeling Transformation	12 days	Wed 11/20/13	Thu 12/5/13		
9	Data Modeling	5 days	Wed 11/20/13	Tue 11/26/13	7	Group - 5 Team
10	Data Integrity	3 days	Wed 11/27/13	Fri 11/29/13	9	Group - 5 Team
11	Security	2 days	Mon 12/2/13	Tue 12/3/13	10	Group - 5 Team
12	Disaster Planning	2 days	Wed 12/4/13	Thu 12/5/13	11	Group - 5 Team
13	Data Modeling Evaluation	5 days	Fri 12/6/13	Thu 12/12/13		
14	Verify Data Warehouse Administration	1 day	Fri 12/6/13	Fri 12/6/13		Group - 5 Team
15	Verify Database Connectivity	2 days	Mon 12/9/13	Tue 12/10/13	14	Group - 5 Team
16	Evaluate Project Design	2 days	Wed 12/11/13	Thu 12/12/13	15	Group - 5 Team
17	Final Preparation	2 days	Fri 12/13/13	Mon 12/16/13		
18	Final Presentation	2 days	Fri 12/13/13	Mon 12/16/13	13	Group - 5 Team

2. DATA MODELING CONTEXT BLUEPRINT

System Architecture Diagram

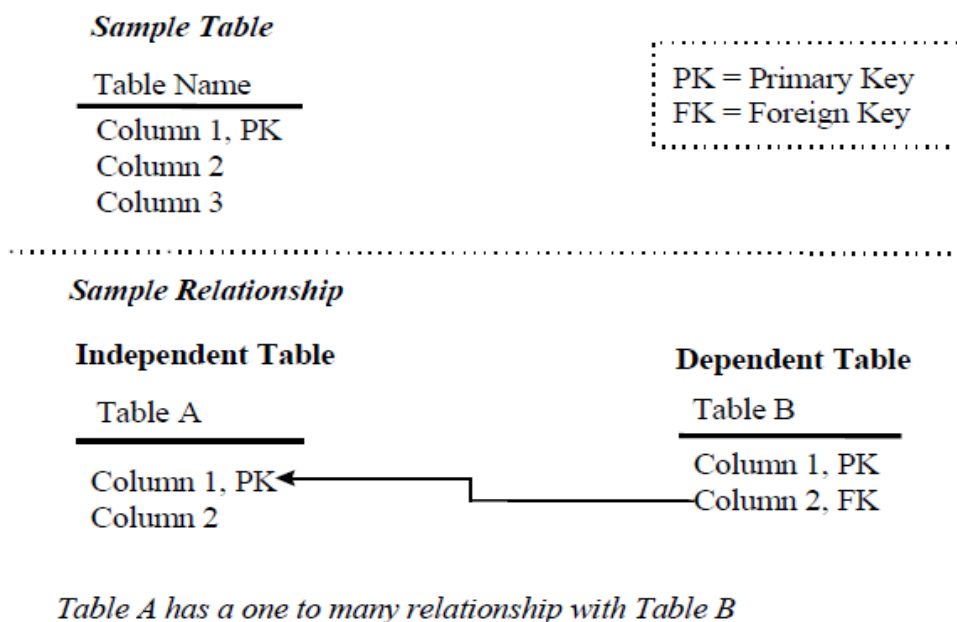


2.1. Design Overview

The Engineering Change Management database implements the persistent data requirements for the Engineering Change Management system. The database is designed to satisfy business rules while maintaining data integrity, consistency, and performance. Database tables are implemented using the Oracle Relational Database Management System (RDBMS). All components of the Engineering Change Management database are described in the following sections; information is presented in sufficient detail to support operational needs.

2.2. Physical Data Model Entity Relationship Diagram

An entity relationship diagram (ERD) is developed for use as a "roadmap" to the Engineering Change Management system database. An ERD is a schematic of the physical data structure that illustrates the dependencies and relationships between database entities, i.e., tables. On ERDs, rectangles and arrows represent database entities as shown below



3. DATA MODELING

Following data modeling techniques are used for our engineering change management project and the details as follows

- Entities
- Entity Types
- Entity Occurrences
- Relationships
- Attributes
- Attribute Roles
- Keys
- Diagramming Techniques

ECM's contextual data model design has different entities to complete the transactions requirement. The purpose of this section is to describe the entities within the ECM system.

3.1. Entity Details are

- Document (DMS)^{21,28,34,36} – This entity has the details of the engineering document requirements.
- Material – It is the type of end material
- Bill of Material (BOM) – Set of component to build end material
- ECM – Engineering change master
- Users – User account information
- Routing(work flow) – ECM approval information
- Material Type – Type information of a material

3.2. Entity Type

Entity	Entity Type
Document	Drawing
Document	Specification
Material	Finished Good
Material	Semi-Finished Good
BOM(Bill of Material)	Engineering BOM
BOM(Bill of Material)	Material BOM
ECM(Engineering Change Master)	ECR/ECO
ECM(Engineering Change Master)	ECM Lite
User	ECM Coordinator
User	ECM Approver
Material Type	Types of Material

3.3. Entity Attributes

Entity	Attributes
Document	Type
Document	Document Number
Document	Version
Document	Material
Document	User
Document	Status
Document	Department
Document	Change Number
Document	Files
Material	Material
Material	Created On
Material	Created by
Material	Status
Material	Material Type
Material	Industry

Material	Material Group
Material	Material Old Number
Material	Base Unit
Material	Gross Weight
Material	Net Weight
BOM	Material Number
BOM	BOM Number
BOM	Component
BOM	Alternate BOM
BOM	Valid From
BOM	Change No.
BOM	Base Unit
BOM	Base quantity
BOM	Description
BOM	Department
BOM	Status
ECM	Change Number
ECM	Status
ECM	Auth Group
ECM	Valid From
ECM	Created on
ECM	Created by
ECM	Description
ECM	Change Type
ECM	Release Key
Material Type	Material Type
Material Type	Material Type description

4. INSTANCE OF EACH ENTITY’S REQUIREMENTS WILL BE EXPLAINED IN DETAIL SECTION BELOW

4.1. Document

Table 1 Contains types of the document data to be used in ECM table

Type	Document Number	Version	Material	User	Status	Department	Change Number	Files
SWD	30002331	2	1000001	SGADAUM	Release	Engineering	50000540	Drawing.pdf
SWP	30002331	1	1000002	IMUTHALAGU	Create	Manufacturing	50000540	Spec.doc

4.2. Material

Table 2 Contains material data to be used in Bill of Material table

Material	Created On	Created by	Status	Material Type	Industry	Material Group	Material Old Number	Base Unit	Gross Weight	Net Weight
1000001	6/15/2012	IMUTHALAGU	Create	Finished Goods	Mechanical	55121600	87725	EA	0.001	0.001

4.3. Bill of Material (BOM)

Table 3 Contains Bill of Material data to be used in ECM table

Material Number	BOM Number	Component	Alternate BOM	Valid From	Change No.	Base Unit	Base quantity	Description	Department	Status
1000001	2648	12000001	1	2/9/2012	5000001	EA	1	Screen	Engineering	Release

4.4. Engineering Change Management (ECM)

Table 4 Contains ECM data

Change Number	Status	Auth Group	Valid From	Created on	Created by	Description	Change Type	Release Key
5000033	Release	XYZ	11/18/2010	11/18/2010	IMUTH	BOM Change	ECM Lite	1

4.5. User

Table 5 Contains user’s information to be used in ECM table

User	Person	E-Mail Id	Location	First Name	Last Name	Role
IMUTH	104215	dddd@gmail.com	Milwaukee	M	I	ECM-Coordinator
SGADAUM	21221	bbbb@gmail.com	Phoenix	S	G	ECR-Approver

4.6. Routing

Table 6 Contains approval information to be used in ECM table

Department	Pre-Check	Approve ECR	Execute Change	Approve ECO	Release
Engineering	ECM-Coordinator	ECR-Approver	ECM-Executor	ECO-Approver	ECM-Coordinator

4.6.1. Material Type

Table 1 Contains Type of Material data to be used in Material table

Material Type	Material Type description
FERT	Finished Good
HALB	Semi-Finished Good
HAWA	Trading Good

4.6.2. Department Type

Table 2 Contains Company Department Information to be used in BOM, Document and Routing Tables for ECM approval process

Department Type	Department Type description
Engineering	Engineering
Quality	Quality
Manufacturing	Manufacturing

4.6.3. Role

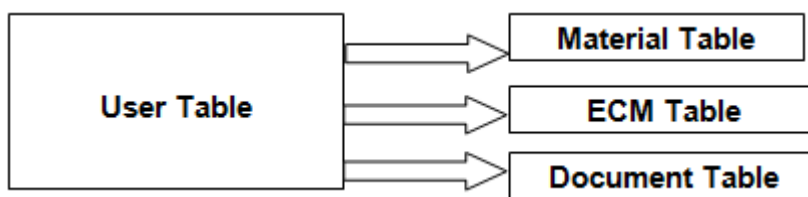
Table 3 Contains role information to be used in Routing and User Tables

Role	Role description
ECM-Coordinator	ECM Coordinator
ECO-Approver	ECO Approver
ECR-Approver	ECR Approver

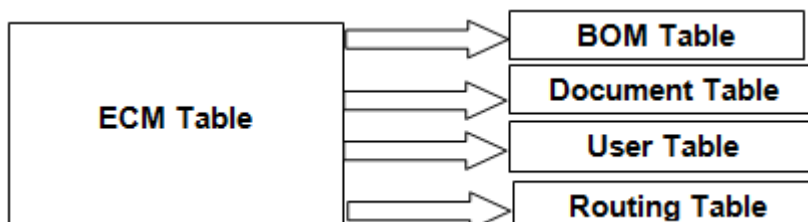
5. TO-BE-RELATIONSHIP (ER)

The relationships have been identified and defined in the relationship definitions

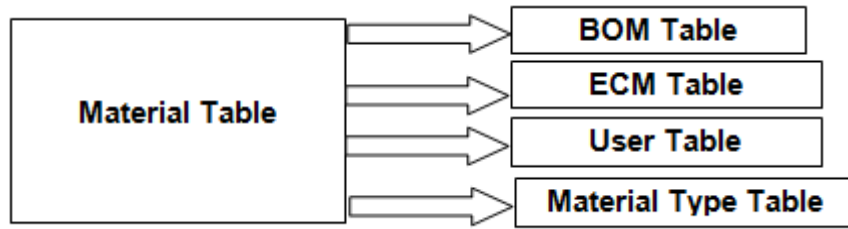
User Table Relationship



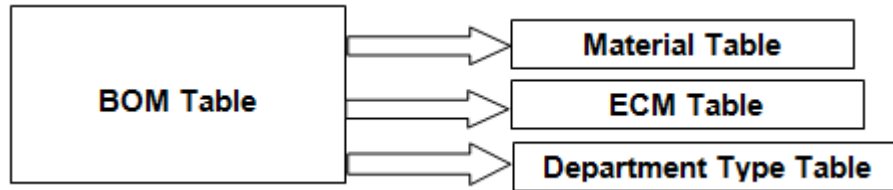
ECM Table Relationship



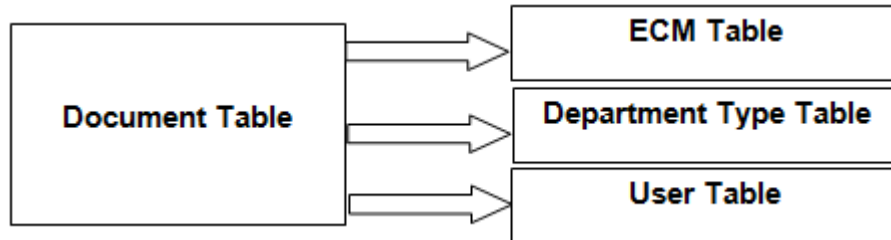
Material Table Relationship



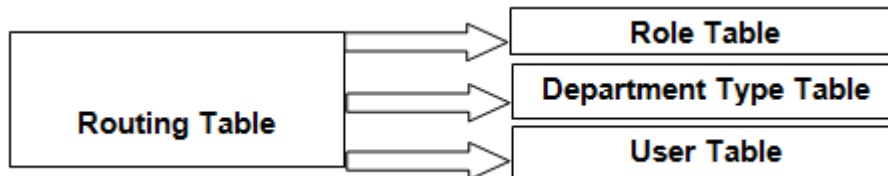
BOM Table Relationship



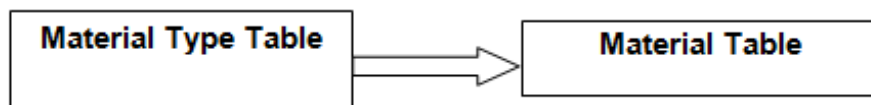
Document Table Relationship



Routing Table Relationship



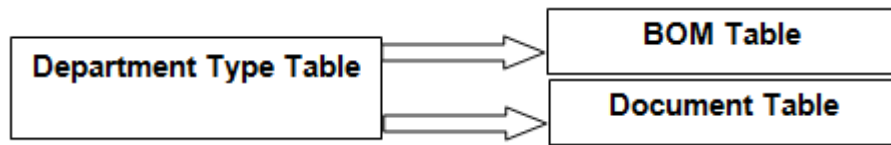
Material Type Table Relationship



Role Table Relationship



Department Type Table Relationship



MARA : General Material Data

Technical Name	Long Text
MATNR	Material Number
ERSDA	Created On
ERNAM	Name of Person who Created the Object
LAEDA	Date of Last Change
AENAM	Name of Person Who Changed Object
VPSTA	Maintenance status of complete material
PSTAT	Maintenance status
LVORM	Flag Material for Deletion at Client Level
MTART	Material Type
MBSGH	Industry sector
MATKL	Material Group
BISMT	Old material number
MEINS	Base Unit of Measure
BSTME	Purchase Order Unit of Measure
ZEINR	Document number (without document manager)
ZEIAR	Document type (without Document Manager)
ZEIVR	Document version (without Document Manager)
ZEIPO	Pace format of document (without Document M

Navigation

DRAW : Document Info Record

Technical Name	Long Text
DOKAR	Document Type
DOKNR	Document number
DOKVR	Document Version
DOKTL	Document Part
DIVNAM	Name of person responsible
DOKST	Document Status
LABOR	Laboratory/Design office
AENNR	Change Number
WERKA	Plant
LOEOK	Deletion indicator
CADKZ	CAD Indicator
PRENR	Document number of superior document
PREVR	Document version of superior document
PRETL	Document Part of Superior Document
PREAR	Document type of the superior document
BEGRU	Authorization Group
FILEP	Original of document
DTTRG	Name of Data Center
DAPPL	Application

MAST : Material to BOM Link

Technic	Long Text
MATNR	Material Number
WERKS	Plant
STLAN	BOM Usage
STLNR	Bill of material
STLAL	Alternative BOM
LOSVN	From Lot Size
LOSBS	To Lot Size
ANDAT	Date record created on
ANNAM	User who created record
AEDAT	Changed On
AENAM	Name of Person Who Changed Object
CSLTY	Indicator configured material (material variant)

AENR : Change Master

Technic	Long Text
AENNR	Change Number
AENST	Status of change number
AENBE	Authorization group for change master record
DATUV	Valid-From Date
TECHV	Technical status from
ANDAT	Date record created on
ANNAM	User who created record
AEDAT	Date of Last Change
AENAM	Name of person who changed object
AETKT	Change Number Description
LTSJP	Language: The long text was stored in this language
AREGR	Reason for change
CCART	Change type
CCSTM	Maximum partial status keys in engineering change management
DYDAT	Indicator: change number with dynamic date
CONTI	Digital signature (process improvement)
AEPLN	Change number function
UESTR	Indicator: Overriding possible
RLKEY	Release Key for Change Master Record
LVORM	Deletion Flag for Change Number (Reorganization)
CLINT	Internal class number describing effectivity type

USR21 : User Name/Address Key Assignment

Technical Name	Long Text
USNAME	User Name in User Master Record
PERNUMBER	Person number
ADDRNUMBER	Address number
KOSTL	Cost center
START MENU	Start menu
IDADTYPE	Address Type of the Identity
BPPERSON	Business Partner GUID
ORGANIZATION	Business Partner GUID
RESPONSIBLE	User Responsible for Technical User Account
TECHDESC	Description of the Technical User Account
IDENTITY GUID	GUID of the Identity

STKO : BOM Header

Technic	Long Text
STLTY	BOM category
STLNR	Bill of material
STLAL	Alternative BOM
STK02	Internal counter
DATUV	Valid-From Date
TECHV	Technical status from
AENNR	Change Number
LOEIK	Deletion Indicator
LOEIKZ	Deletion flag for BOMs
VSKZL	Previous header counter
ANDAT	Date record created on
ANNAM	User who created record
AEDAT	Changed On
AENAM	Name of Person Who Changed Object

6. PERFORMANCE IMPROVEMENT

Column(Normalization)	Source Table or Entity	Rules and methods for maintaining integrity
Document Number	Document	Primary Key
Material	Document	Foreign Key
User	Document	Foreign Key
Material	Material	Primary Key
Created by	Material	Foreign Key
Material Number	BOM	Foreign Key
BOM Number	BOM	Primary Key
Component	BOM	Foreign Key
Change No.	BOM	Foreign Key
Change Number	ECM	Primary Key
Created by	ECM	Foreign Key
User	User	Primary Key
Department	Routing	Primary Key

7. INDEXES

An index provides a means of locating a row in a database table based on the value of a specific column(s), without having to scan all data in the table. When properly implemented, indexes can significantly decrease the time it takes to retrieve data, thereby increasing performance. Oracle allows the definition of two types of indexes, clustered and non-clustered. In a clustered index, the rows in a database table are physically stored in sequence-determined by the index. Clustered indexes are particularly useful, when the data is frequently retrieved in sequential order. Only one clustered index may be defined per table. Non-clustered indexes differ from their clustered counterpart, in that, data is not physically stored in sorted order-newly added rows are stored at the end of the related database table.

Index Type Key	
Index Type Key	Description
P	Primary Key
F	Foreign Key
U	Unique - Only one for the column code combination
C	Clustered or non-clustered index

Index List						
Table	Index Name	Column Name(s)	P	F	U	C
Document	x_documentnumber	Document_Number	X	N	N	Y

Table	Index Name	Column Name(s)	P	F	U	C
Material	X_Material	Material_Number	X	N	N	Y

Table	Index Name	Column Name(s)	P	F	U	C
BOM	X_BOM_Number	BOM_Number	X	N	N	Y
BOM	X_Component	Component	N	Y	N	Y

Table	Index Name	Column Name(s)	P	F	U	C
User	X_User_id	User_id	X	N	N	N

Table	Index Name	Column Name(s)	P	F	U	C
Routing	X_Routing_id	Routing_id	X	N	N	Y

Table	Index Name	Column Name(s)	P	F	U	C
Material Type	X_Material_TYPE	Material_Type	X	N	N	N

7.1. Normalization

Change Management Database Design project has many normalized tables and CASE tool is helping us to organize and control the database design process. It allows our project team to have a common view about the lifecycle of database design. Database normalization supports our project data into multiple related tables and these tables are being joined with Primary/Foreign Keys. It removes data redundancy, inconsistency and it ensures the data integrity as well as system performance.

Change Management Project Data has been separated into multiple tables such as

- Document – This entity has the details of the engineering document requirements.
- Material – It is the type of end material
- Bill of Material (BOM) – Set of component to build end material
- ECM ^{[4],[5],[6],[8],[11],[13],[16],[19],[21],[23],[26],[29],[33]} – Engineering change master
- Users – User account information
- Routing(work flow) – ECM approval information

These above tables are joined together with Primary and Foreign Keys. This approach ensures that the data are tightly integrated data each other.

7.2. Caches

A cache is a block of memory that is used by Oracle to retain and manage pages that are currently being processed. By default, each database contains three caches:

- Data cache - retains most recently accessed data and index pages
- Procedure cache - retains most recently accessed stored procedure pages
- User transaction log cache - transaction log pages that have not yet been written to disk for each use

The data cache can be further subdivided into named caches. A *named cache* is a block of memory that is named and used by the DBMS to store data pages for select tables and/or indexes. Assigning a database table to named cache causes accessed pages to be loaded into memory and retained. The named cache does not need to be allocated to accommodate the entire database table since the DBMS manages the cache according to use. Named caches greatly increase performance by eliminating the time associated for disk input and output (I/O). There are no named caches that are currently defined for the ECM ^{[4],[5],[6],[8],[11],[13],[16],[19],[21],[23],[26],[29],[33]} Subsystem database. Named caches may be defined as the memory usage of the ECM database becomes better known. As named caches are defined this portion of the document will be updated.

8. CONCLUSION

A streamlined system is required to analyze the ECM [4],[5],[6],[8],[11],[13],[16],[19],[21],[23],[26],[29],[33] request, record and implement the changes to the customer and future project enhancement. Track the changes done historically to the product, so that the life cycle has the product has identified.

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