Transformer Performance Database

A Value Proposition for an Industry-wide Equipment Performance Database (IDB) of Substation Transformers

1012357

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Technical Update, November, 2006

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ABSTRACT

Effective equipment planning, maintenance, refurbishment and replacement decisions require knowledge about asset performance and the ability to predict future performance. To be well informed about a power transformer's expected performance; one must analyze both the asset's individual historical performance data and that of other assets of similar characteristics or type. Similarly, fleet management decisions are best made with an understanding of expected performance of the group. Transformer performance varies considerably because of differences in design, manufacturing, and application. Therefore, risk identification using generic transformer failure rates is not sufficient to meet the current business and technical demands for risk management placed on power delivery planners, asset and maintenance managers. Statistically valid information is required identified by:

- Failure type
- Operational history
- Maintenance history

Design based on specific:

- Family
- Make
- Model
- Application
- Age

To this end, EPRI has undertaken work to collect the needed data. By including data from numerous utilities, meaningful reliability, maintenance and operating statistics can be generated. Some of the uses include:

- Population age distribution
- Failure mode distribution
- Lifetime distributions or probability density function (hazard rates)

EPRI's Transformer Industry-wide Data Base is a collaborative effort to pool appropriate transformer operating and failure data in order to assemble a statistically valid population of many types of transformers.

Building on the work of the Electric Power Research Institute Industry Database for Cables, the goals of this project are to design, develop, populate, maintain and extract valuable information from an Industry Database for power transformers (IDB). The IDB design will be flexible enough to contain data from the perspective of capability, condition, degradation, and risk assessment collected over the life of a transformer. The project will identify data requirements and develop standardized database models for equipment performance analysis and

benchmarking. Using industry wide data and integrating information currently contained in separate documents and databases, this project will provide utilities with reliability, operational and performance data, and information resources not available to an individual company.

The project will:

- Use an open architecture to allow integration with existing utility databases and integration tools
- Provide templates for data collection as well as performance reporting for both the IDB and utility internal uses
- Enable multi-utility data collection (including on-line data) needed to meet business needs
- Document, track, and analyze transformer failures and troubles with the defined data elements (cause, mode, root cause, analysis, etc.) and compare with industry averages
- Provide tools to project future transformer performance, reliability, and maintenance needs

In the first phase of this project, reported here, EPRI has developed a prototype IDB architecture using the CIM (Common Information Model) naming conventions. In the second phase, the objectives will be to populate the IDB with data from each participating utility and develop analysis tools to provide the requisite information. The results of this second phase will be made available to all participating utilities in a secured manner. Sensitive utility data will be processed confidentially and shared only on a generic or summary basis.

ACKNOWLEDGEMENTS

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1
INTRODUCTION

Best-practice maintenance and asset Management decisions are based upon the ability to understand risks associated with actual equipment condition and performance. There are four key steps which are necessary to understand this risk. They are:

- Understanding existing performance
- Understanding required performance
- Projecting future performance
- Understanding how to bridge gaps

Therefore, effective equipment planning, maintenance, refurbishment and replacement decisions require knowledge about asset performance and the ability to predict future performance. To be well informed about a power transformer's expected performance, one must analyze both the asset's individual historical performance data and that of other assets of similar characteristics or type. Similarly, fleet management decisions are best made with an understanding of expected performance of the group. Transformer performance varies considerably because of differences in design, manufacturing, and application. Consequently, risk identification using generic transformer failure rates is not sufficient to meet the current business and technical demands for risk management placed on power delivery planners, asset and maintenance managers. Statistically valid information is required identified by:

- Failure type
- Operational history
- Maintenance history

Design based on specific:

- Family
- Make
- Model
- Application
- Age

Background

The power transformer is a major capital asset in a utilities' power system. It can step-up voltage from a generating station to transmission voltage levels, it can control power flow (phase-shifting transformer) between systems and it steps voltage down in substations to distribution voltages. Given its importance in a power system it is no wonder that the failure of one of these assets should warrant investigation and that the utilities should want to keep track of their serviceability and reliability.

Over the past fifty years various attempts have been made to collect power transformer performance data. At this time, there is no comprehensive data base available to EPRI members that can be used for the kinds of analysis required to meet today's business needs.

Challenges

For all of the above-mentioned reasons, asset management tools are needed to justify and guide the solutions, meet the near term cost and reliability challenges and provide the business case for future technology and business transformations. Equipment Performance Data is necessary to be able to project equipment failure rates and costs as the equipment ages and its condition degrades. The key requirements – equipment failure models and equipment failure rates provide the motivation for developing an industry-wide performance database as a tool for planning and asset management.

Few utilities have a large enough population of like transformers from which they can develop accurate failure models. Most utilities have transformer populations made up of numerous models from a diverse set of manufacturers making it very difficult to predict the true expected reliability of any one specific model. Even when the population of a specific model is large, the utility many times finds that its operating experience and historical data are limited. EPRI's Transformer IDB is a collaborative effort to pool appropriate transformer operating and failure data in order to assemble a statistically valid population of many types of transformers.

Objectives – Why IDB for Transformers?

The sharing of failure and trouble experiences on a detailed and confidential basis is necessary in order for the industry to build advanced predictive models and to better determine the expected lives of critical assets. Utilities are very interested in learning from others and sharing data but have not had a suitable vehicle or model to share that information. EPRI not only has the vehicle to share data on a confidential basis but also has developed algorithms that can "mine" this information and provide the participating utility with expert diagnostics and analysis.

EPRI's Industry Wide Performance Database -Transformers (IDB) models power transformer assets and failures. Included in the database are asset attributes to allow the segregation and analysis by manufacturer, model, application and risk exposure.

The objective of this project is to develop a transformer performance database that can be used by the industry to predict transformer reliability for a variety of risk profiles. Using basic nameplate and precursory failure information, this data base tries to overcome the following challenges:

- Generic transformer reliability models are inadequate for complex decision support.
- Company data does not statistically represent diverse asset population subsets.

- Difficult to identify and track performance problems within groups, e.g. design type or age bracket.
- No easy way to benchmark across companies matching “apples to apples.”
  - O/M Practices
  - Design Issues
  - Application

The database specification includes physical asset information, trouble and failure events for use in life assessment and component analysis. The specification also allows the database to be used in maintenance and asset management optimization – including strategies for replacement, to identify design and material problems.

2 APPROACH

Given the past experience with Transformer Data Collection and Management, EPRI has embarked on a project to establish a Transformer Database which can be used by any member utility to enter data and receive reports via the internet and/or manage their data within their own utility.

The EPRI Industry Wide Database for transformers will use a flexible architecture, user friendly tools and web enabled data entry and reporting. The data required for the in-service transformer population will be determined using transformer experts, the IEEE Guide C57.117 and CIGRE information. The specification of the amount and type of data supplied must also consider its availability to the utility. If data is unavailable to the utility then the database will fall into disuse. The emphasis here is that the database will require the minimum amount of data to assure it accuracy and assure confidence in its query results.

Data entry will use templates with drop down menus to assist the utility in entering the proper data with the least amount of effort. This applies to population data entry and failure data entry.

Query templates will be used to assist the utility in obtaining customized reports. Based on the desires of the member utilities standard reports can be developed and broadcast to the utility over the internet.

The preliminary data model includes:

Physical Asset Information

- Manufacturer
- Design Characteristics
- Type/Model
- Year of Manufacturer
- Application
- Technical characteristics

Historical Operating Information

- Operating conditions
- Failure Modes
- Failure Causes
- Failure Dates
- Trouble Events
- Trouble Dates

The Model Transformer IDB contains nameplate, operating, failure, and trouble information about each transformer asset. Specific information contained is listed below. A number of drop down menus (indicated by shaded group of fields) are used to facilitate data entry.

Table 2-1
Location Details

Utility Name
Street Address 1
City
State/Province
Zip/Postal Code
Country
Modify Date
Contact Name
Phone
e-mail
Substation
Substation ID
Transformer ID
Substation
Operating Number
Bank ID
Bank

Table 2-2
Application

Application
Substation Trans.
Transmission Tie
Generator Step-up
Unit Aux.

Table 2-3
Manufacturer Details

Manufacturer
Plant where manufactured
Serial Number

Table 2-4
Core Design Detail

Core Type
Core form
Shell form

Table 2-5
Vintage Detail

Date of manufacturing
Data of Installation

Table 2-6
Application

Transformer type
Power Transformer
Autotransformer
Regulating Transformer
Phase Shifting Transformer
Shunt Reactor
HVDC Converter Transformer

Table 2-7
Design Specification

Power Rating (Maximum) (MVA)
Nominal Frequency
Voltage Nominal Primary (kV)
Voltage Nominal Secondary (kV)
Voltage Nominal Tertiary (kV)
Primary BIL
Secondary BIL
Tertiary BIL
Neutral BIL
Operating Voltage-Primary
Operating Voltage-Secondary
Winding Configuration - Primary
Winding Configuration - Secondary
Winding Configuration - Tertiary
Phases

Table 2-8
Cooling System Details

Cooling Class	
NEW DESIGNATION	OLD DESIGNATION
ONAN	OA
ONAF	FA
ONAN/ONAF/ONAF	OA/FA/FA
ONAN/ONAF/OFAF	OA/FA/FOA
ONAN/ODAF	OA/FOA

ONAN/ODAF/ODAF	OA/FOA/FOA
OFAF	FOA
OFWF	FOW
ODAF	FOA
ODWF	FOW

Table 2-9
Tap Changer Details

NO LOAD TAP CHANGER
Temperature Rise
55/65
65
55
Winding Insulation
Oil type
mineral oil
Non-mineral oil

Oil Preservation System
Nitrogen pressure reg.
Conservator-Bladder
Sealed nitrogen blanket
On-Load Tap Changer Model
Manufacturer
Type
Reactance bridging/arc in liquid
Reactance bridging/arc in vacuum
Resistance bridging/arc in liquid
Resistance bridging/arc in vacuum
Other (specify)
Current Rating
Number of Phases
Nominal Voltage
Number of Taps
In-Service Date

Table 2-10
Failure Report Details

FAILURE/TROUBLE REPORT SECTION (THIS SECTION FILED IN ONLY IN EVENT OF A TROUBLE/FAILURE
REASON FOR REPORT
Failure with forced outage
Failure with scheduled outage
Defect
Other

Table 2-11
Failed Component Location Details

FAILURE LOCATION
H Bushing
X bushing
Y Bushing
Leads-terminal board
H winding
X winding
Y winding
Tap winding
connections
Magnetic circuit
Shielding insulation
core insulation
Core clamping
Fluid circulating system
Tank
Heat exchangers
No Load Tap Changer
Load Tap Changer
CTs
Auxiliary equipment
Other
Unknown

Table 2-12
Failure Result Details

FAILURE RESULTED IN:
Fluid contamination
Excess temperatures
Dielectric breakdown
Impedance change
High combustible gas
Loss of pumps
Loss of fans
Tap changer malfunction
Fire
Expulsion of insulating fluid
Rupture of tank
Other (specify)

Table 2-13
Failure Cause Details

CAUSE OF FAILURE
Electrical design
Mechanical design
Manufacturing
Inadequate short circuit strength
Electrical workmanship
Mechanical workmanship
Improper storage
Improper installation
Improper maintenance
Improper protection
Overload
Excessive short circuit duty
Loss of cooling
Operation error
Transportation
Lightning
Earthquake
Animals
Vandalism
Sabotage
Unknown
Other (specify)
Loading at time of failure
Estimated Fault Current
Weather
Special Conditions

Table 2-14
Failure Result

Removed from Service (Date)
Transformer Disposition
Rewound and returned to service
Repaired and returned to service
Transformer Scrapped

Repaired by Whom?

Date returned to service

3
PROOF OF CONCEPT - DEMONSTRATION

Initial development has resulted in the construction of a preliminary database structure. Various computer “screen shots” are presented in this section to demonstrate the “user friendliness” and flexibility of the database. The figures will start with log-in and proceed through data entry and finally show a search. The database uses SQL server and will reside on an EPRI server. There will be security built into the system that will allow the user to view only data that they can subscribe to. As an example, utility XYZ can view only his utility data and the industry wide database (without utility identification).

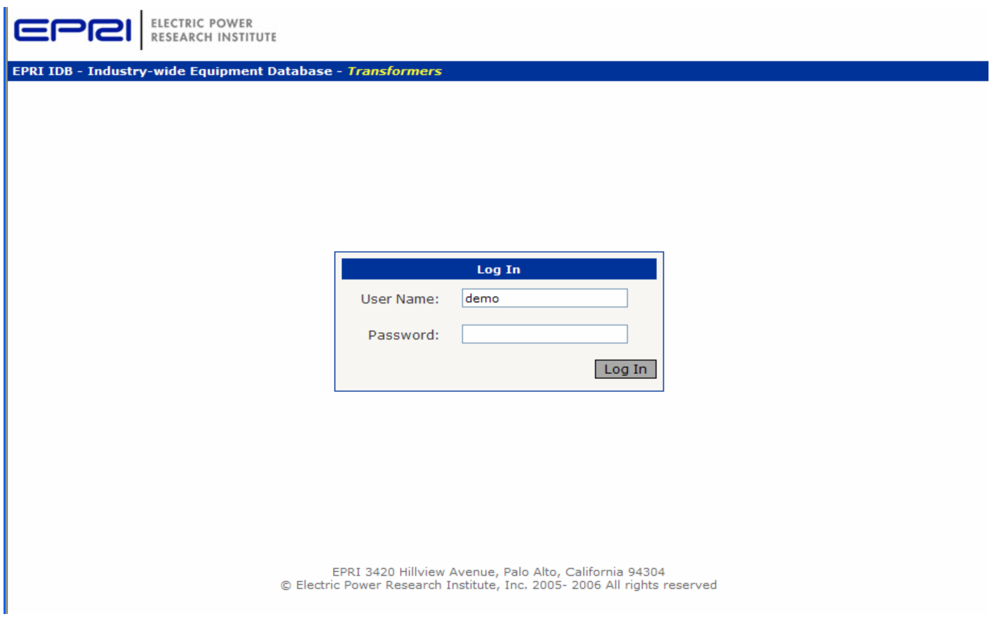


Figure 3-1
Log on Screen

This screen shot shows the window the subscriber will use to log in using their pass word. The user name and password will tell the database if this is a valid subscriber and their allowable activity.

Figure 3-2
Data Entry Selection

In this screen shot the user will be able to elect an activity. The activity could be to enter new data, modify existing data or obtain a report (more on this later).

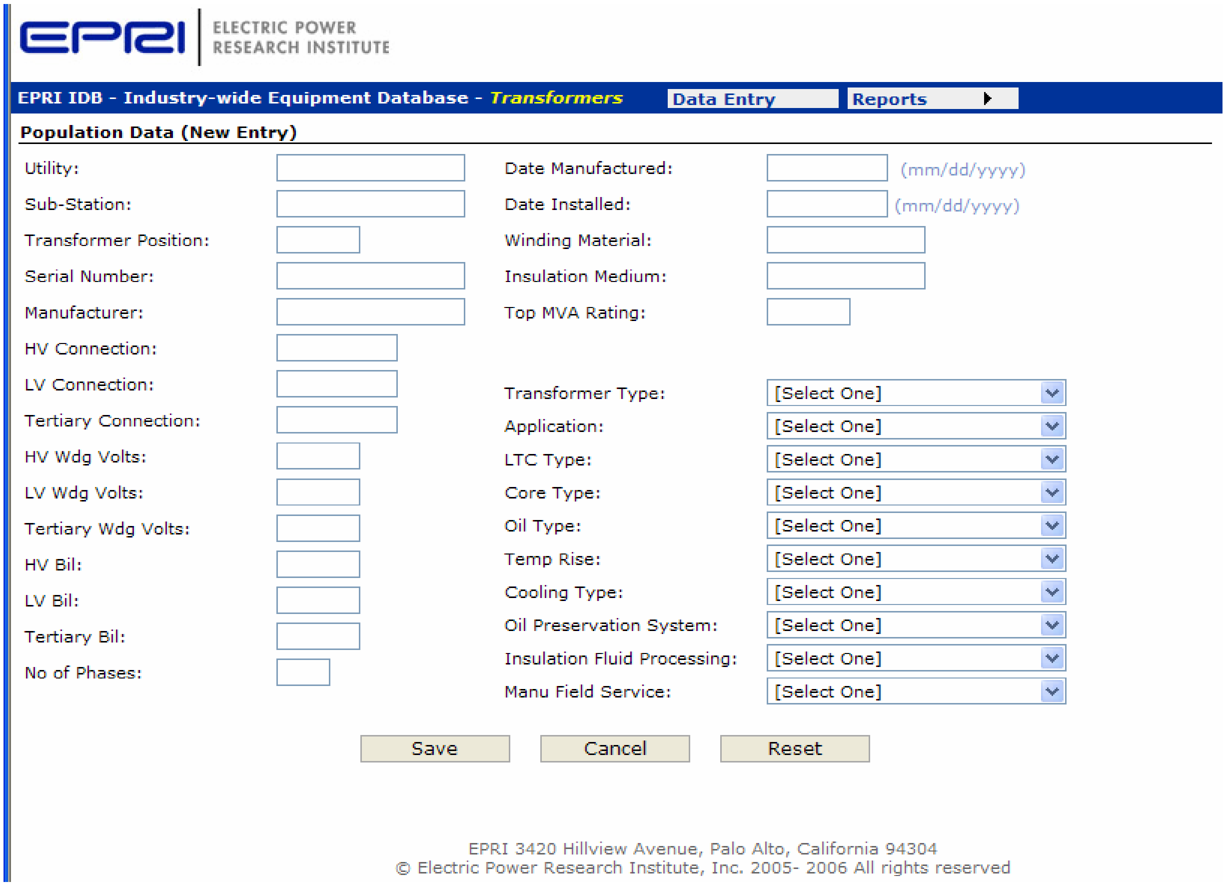
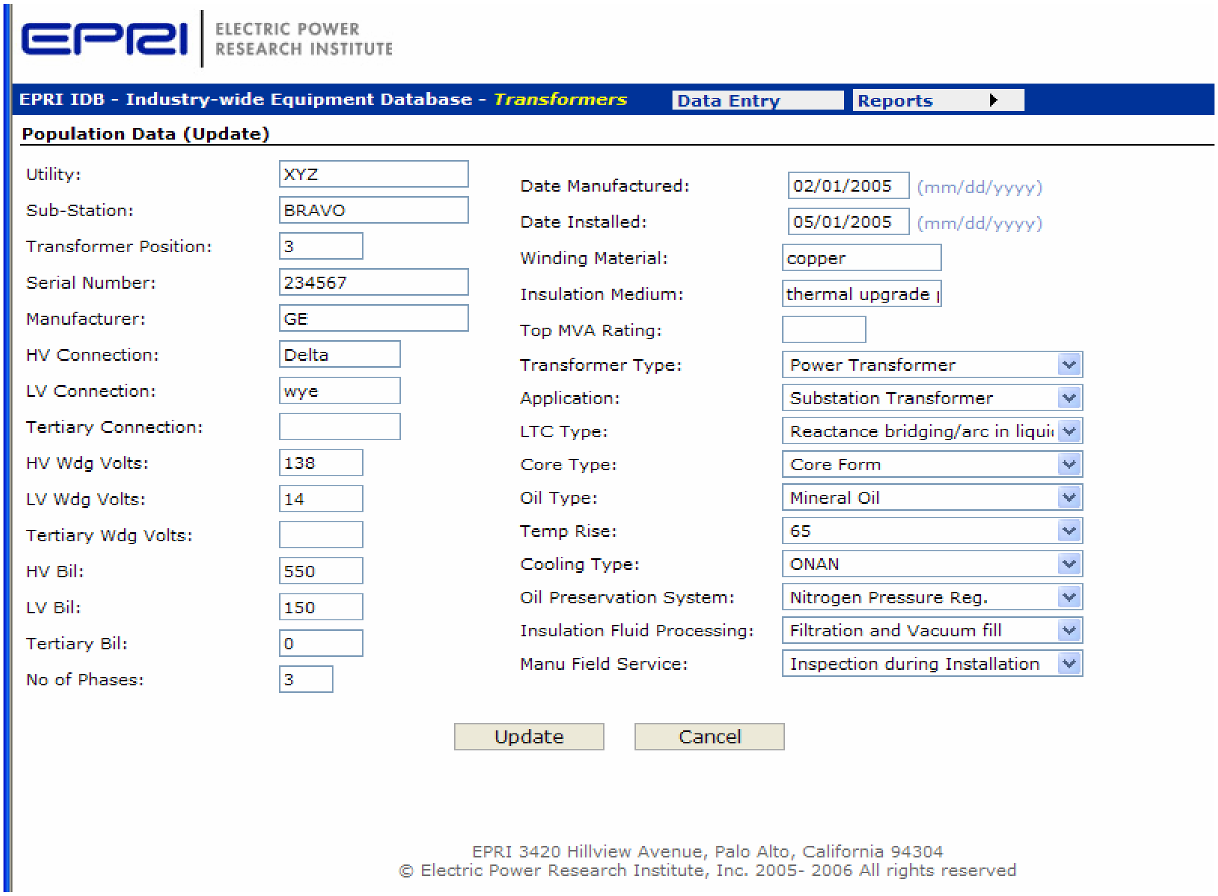


Figure 3-3
Population Data Entry Screen

This screen shot shows the data entry field presently available. Notice the use of drop down menus. This is a user friendly data entry feature.

Figure 3-4
Example – Population Search: By Manufacturer and Serial Number

In order to find an existing record in the data base a user must enter the transformer serial number and the manufacturer. These two fields are unique to a specific transformer. The search will find the record and display it so the modifications can be made to the record.



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EPRI IDB - Industry-wide Equipment Database - *Transformers* | Data Entry | Reports

Population Data (Update)

Utility:	XYZ	Date Manufactured:	02/01/2005 (mm/dd/yyyy)
Sub-Station:	BRAVO	Date Installed:	05/01/2005 (mm/dd/yyyy)
Transformer Position:	3	Winding Material:	copper
Serial Number:	234567	Insulation Medium:	thermal upgrade
Manufacturer:	GE	Top MVA Rating:	
HV Connection:	Delta	Transformer Type:	Power Transformer
LV Connection:	wye	Application:	Substation Transformer
Tertiary Connection:		LTC Type:	Reactance bridging/arc in liqui
HV Wdg Volts:	138	Core Type:	Core Form
LV Wdg Volts:	14	Oil Type:	Mineral Oil
Tertiary Wdg Volts:		Temp Rise:	65
HV Bil:	550	Cooling Type:	ONAN
LV Bil:	150	Oil Preservation System:	Nitrogen Pressure Reg.
Tertiary Bil:	0	Insulation Fluid Processing:	Filtration and Vacuum fill
No of Phases:	3	Manu Field Service:	Inspection during Installation

Update | Cancel

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Figure 3-5
Example – Population Data

In figure 3-4 above the user entered 234567 for the serial number and GE for the manufacturer and found the record below in the data base.

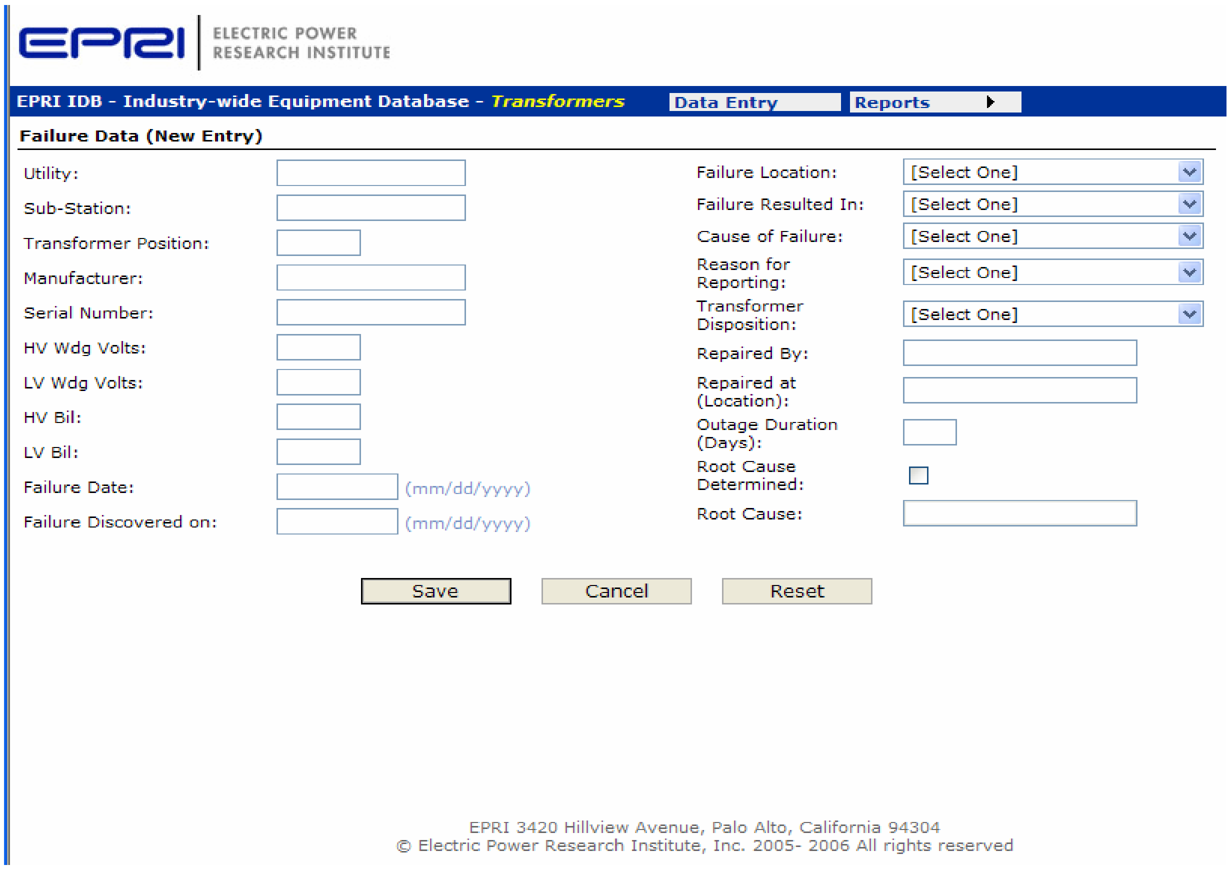


Figure 3-6
Failure Data Entry Screen

The screen shot below shows the data entry window for reporting a failure. Note that many drop down menus are used to facilitate data entry.

Figure 3-7
Failure Search to Modify Failure Data

Once a record has populated the data base then the following screen is used to find the record. Note serial number and manufacturer are required. These two fields are unique to a specific transformer.

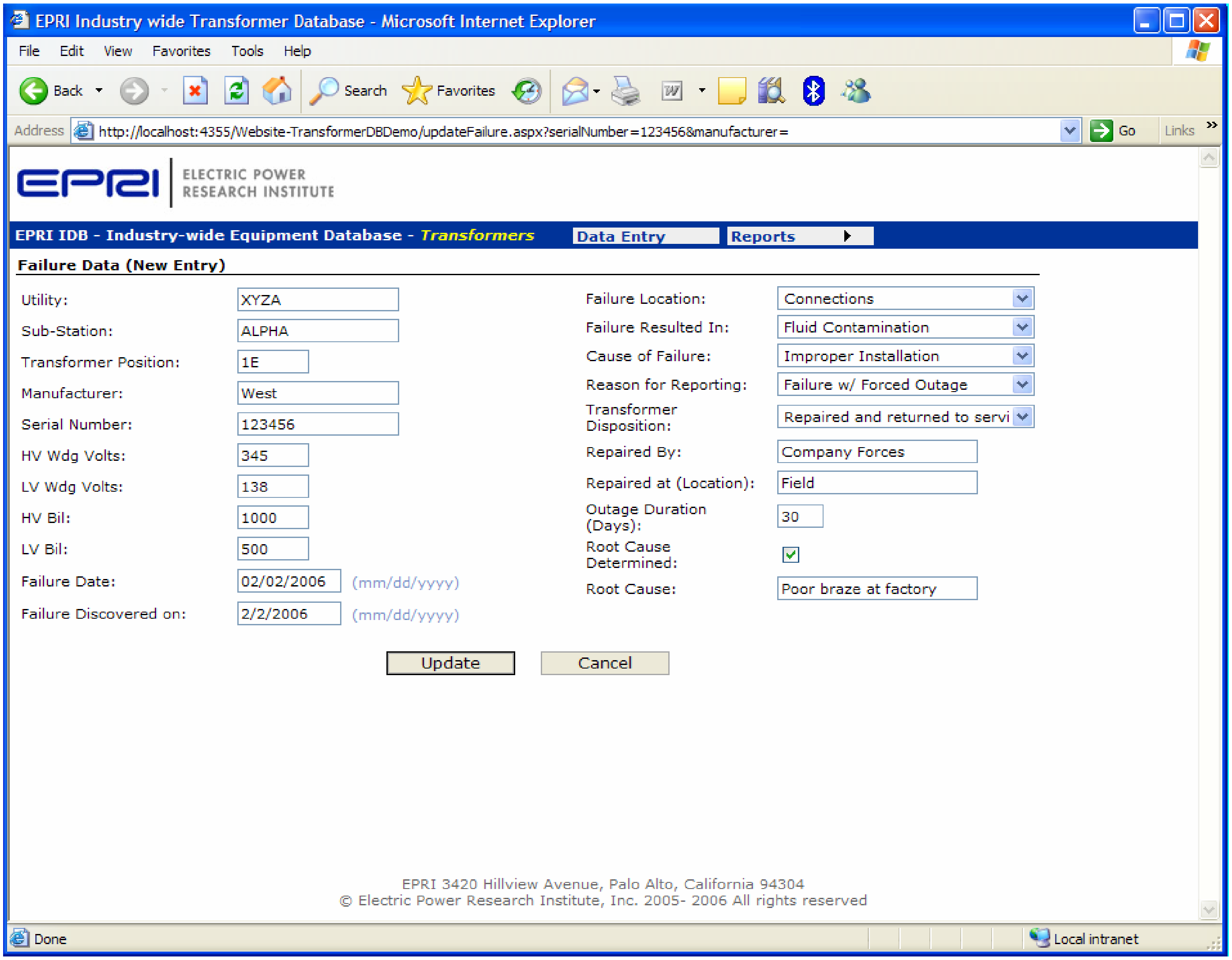


Figure 3-8
Example of Failure Data

Data fields can be modified by searching failure database using Manufacturer and serial number find this data sheet and then data can be added or modified

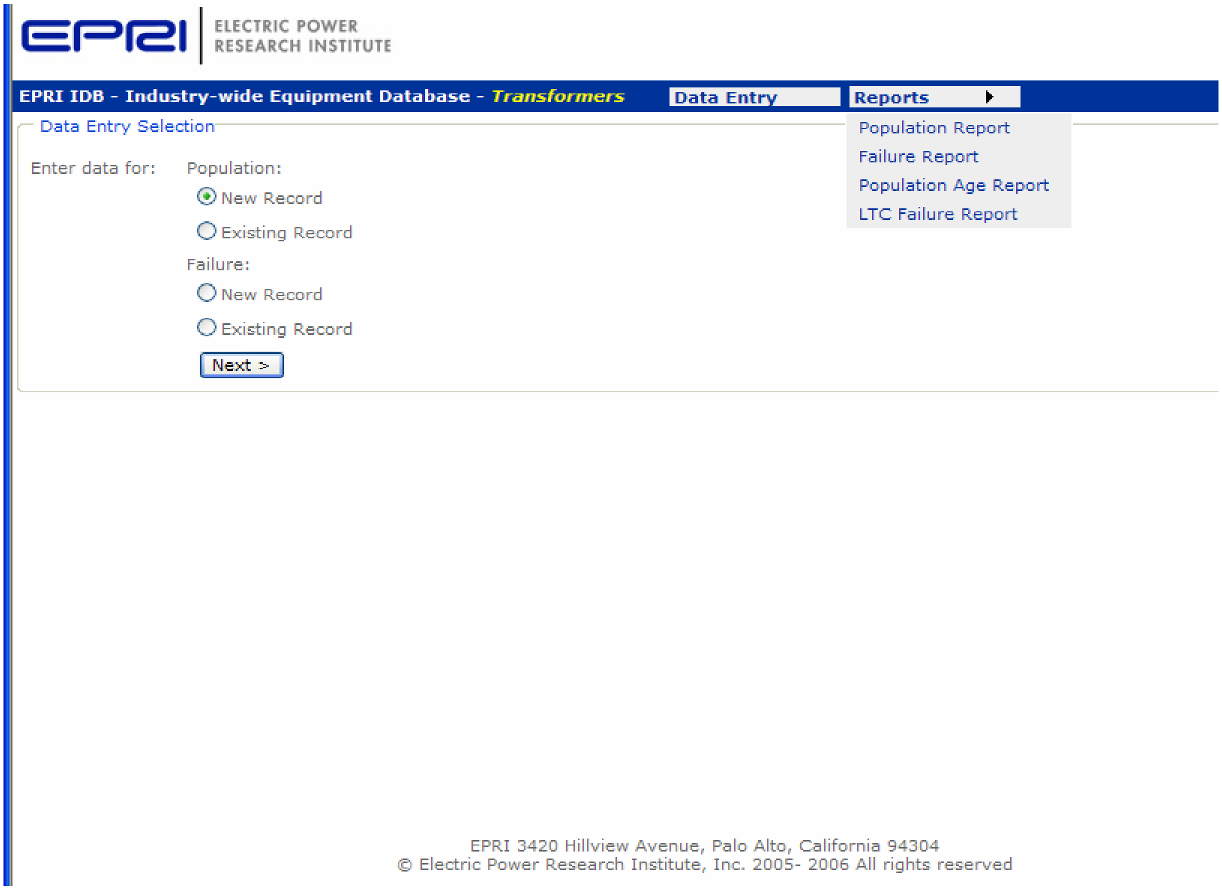
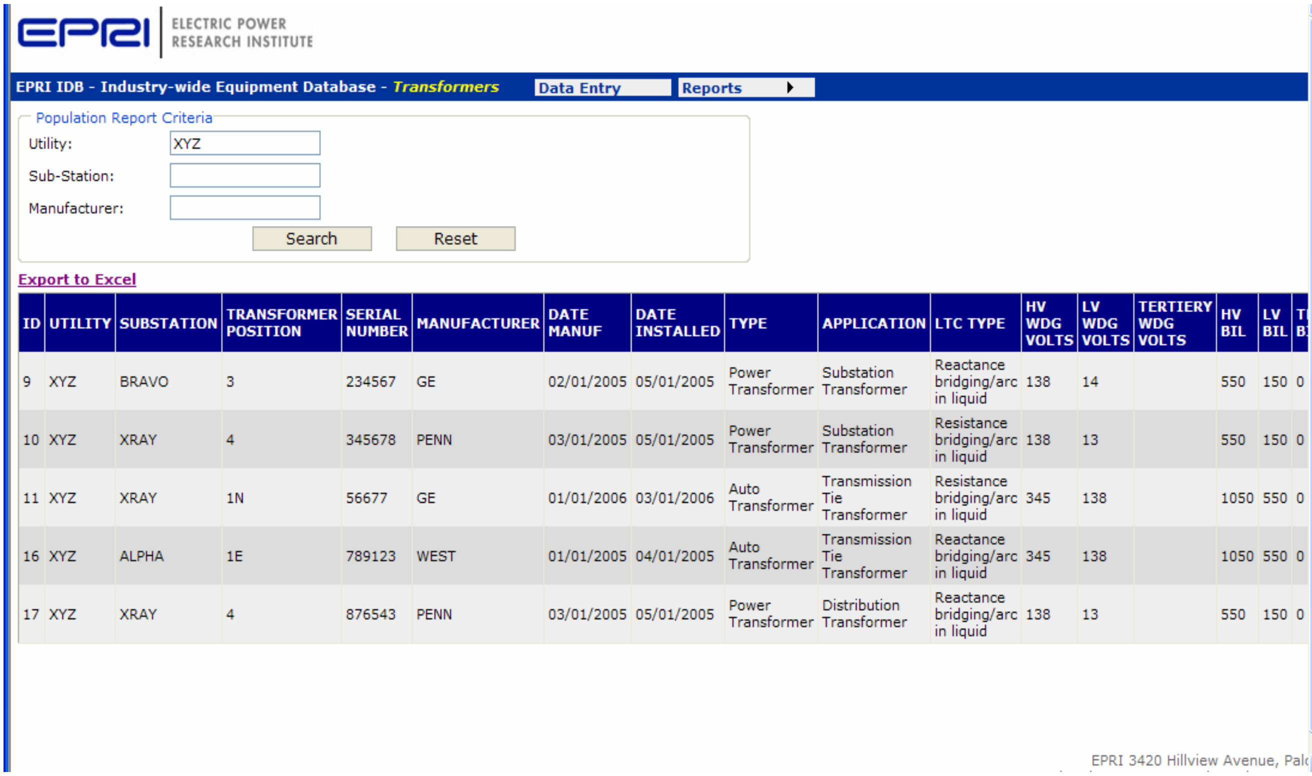


Figure 3-9
Report Selection Screen

This screen is used to select the report desired. Currently there are four reports that can be generated. However, any number of queries can be developed and generate a report if the data field are in the data base. More reports will developed as the subscriber needs are identified.



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EPRI IDB - Industry-wide Equipment Database - *Transformers* | Data Entry | Reports

Population Report Criteria

Utility: XYZ

Sub-Station:

Manufacturer:

Search | Reset

Export to Excel

ID	UTILITY	SUBSTATION	TRANSFORMER POSITION	SERIAL NUMBER	MANUFACTURER	DATE MANUF	DATE INSTALLED	TYPE	APPLICATION	LTC TYPE	HV WDG VOLTS	LV WDG VOLTS	TERTIERY WDG VOLTS	HV BIL	LV BIL	TI BI
9	XYZ	BRAVO	3	234567	GE	02/01/2005	05/01/2005	Power Transformer	Substation Transformer	Reactance bridging/arc in liquid	138	14		550	150	0
10	XYZ	XRAY	4	345678	PENN	03/01/2005	05/01/2005	Power Transformer	Substation Transformer	Resistance bridging/arc in liquid	138	13		550	150	0
11	XYZ	XRAY	1N	56677	GE	01/01/2006	03/01/2006	Auto Transformer	Transmission Tie Transformer	Resistance bridging/arc in liquid	345	138		1050	550	0
16	XYZ	ALPHA	1E	789123	WEST	01/01/2005	04/01/2005	Auto Transformer	Transmission Tie Transformer	Reactance bridging/arc in liquid	345	138		1050	550	0
17	XYZ	XRAY	4	876543	PENN	03/01/2005	05/01/2005	Power Transformer	Distribution Transformer	Reactance bridging/arc in liquid	138	13		550	150	0

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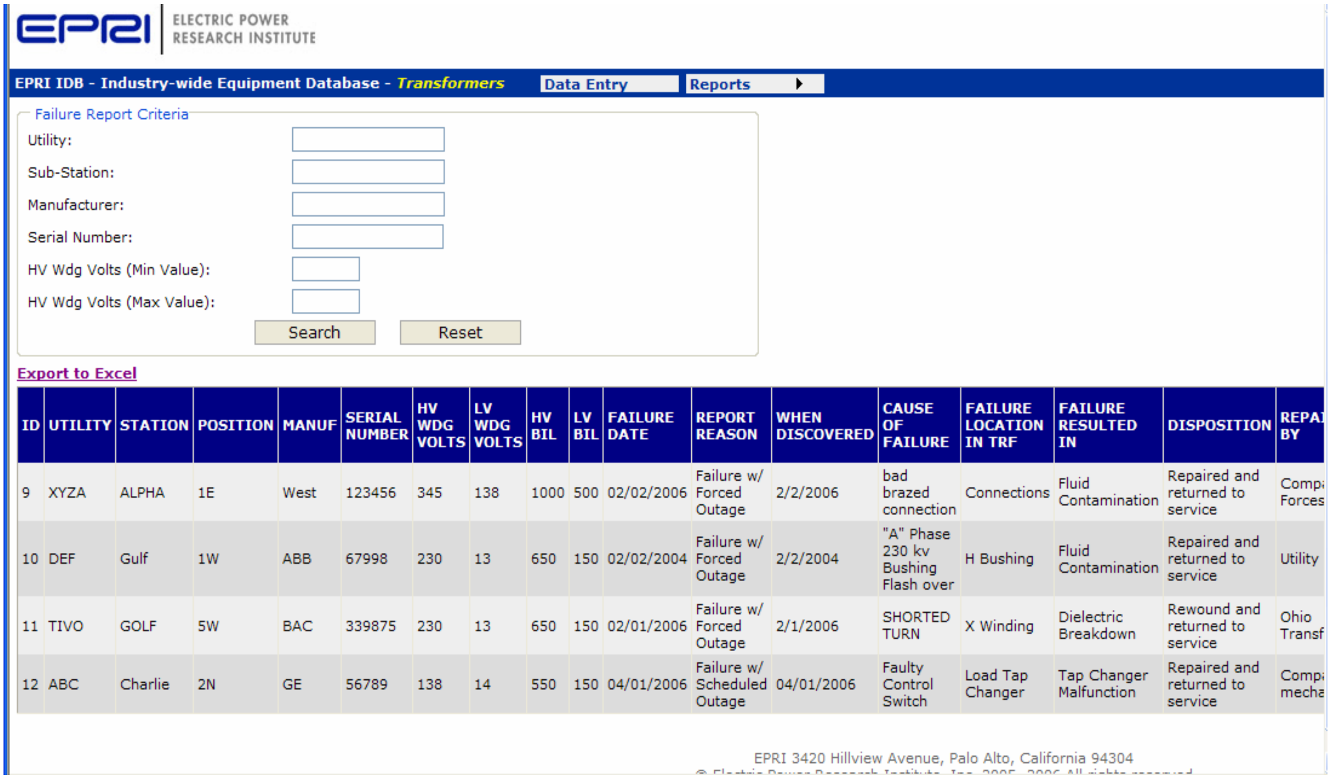
Figure 3-10
Population Report

The screen below is a printout of Utility XYZ population report of their transformers



ID	UTILITY	STATION	POSITION	MANUF	SERIAL NUMBER	HV WDG VOLTS	LV WDG VOLTS	HV BIL	LV BIL	FAILURE DATE	REPORT REASON	WHEN DISCOVERED	CAUSE OF FAILURE	FAILURE LOCATION IN TRF	FAILURE RESULTED IN	DISPOSITION	REPAI BY
9	XYZA	ALPHA	1E	West	123456	345	138	1000	500	02/02/2006	Failure w/ Forced Outage	2/2/2006	bad brazed connection	Connections	Fluid Contamination	Repaired and returned to service	Compa Forces
10	DEF	Gulf	1W	ABB	67998	230	13	650	150	02/02/2004	Failure w/ Forced Outage	2/2/2004	"A" Phase 230 kv Bushing Flash over	H Bushing	Fluid Contamination	Repaired and returned to service	Utility
11	TIVO	GOLF	5W	BAC	339875	230	13	650	150	02/01/2006	Failure w/ Forced Outage	2/1/2006	SHORTED TURN	X Winding	Dielectric Breakdown	Rewound and returned to service	Ohio Transf
12	ABC	Charlie	2N	GE	56789	138	14	550	150	04/01/2006	Failure w/ Scheduled Outage	04/01/2006	Faulty Control Switch	Load Tap Changer	Tap Changer Malfunction	Repaired and returned to service	Compa mecha

Figure 3-11
Report showing all failures in the database

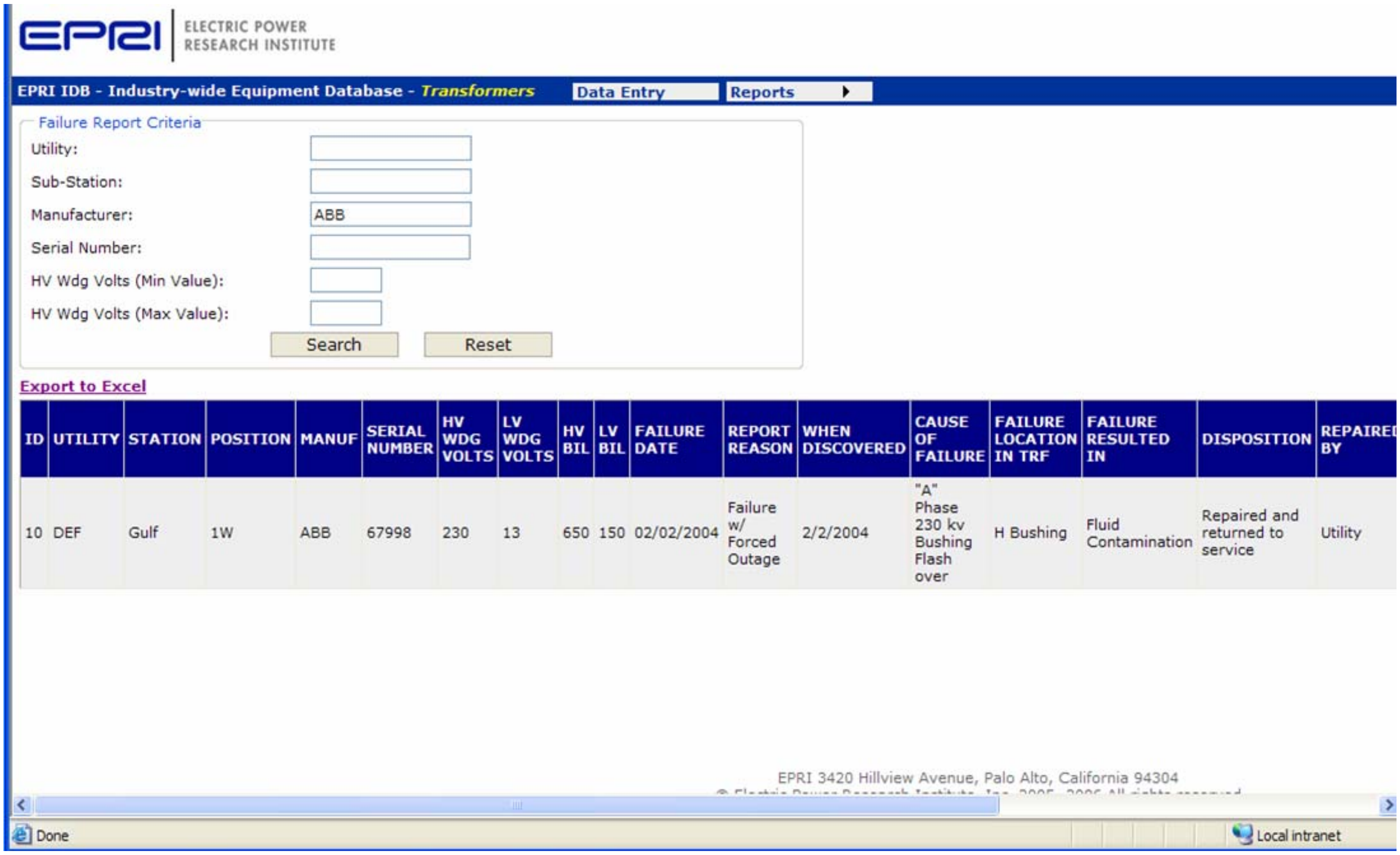
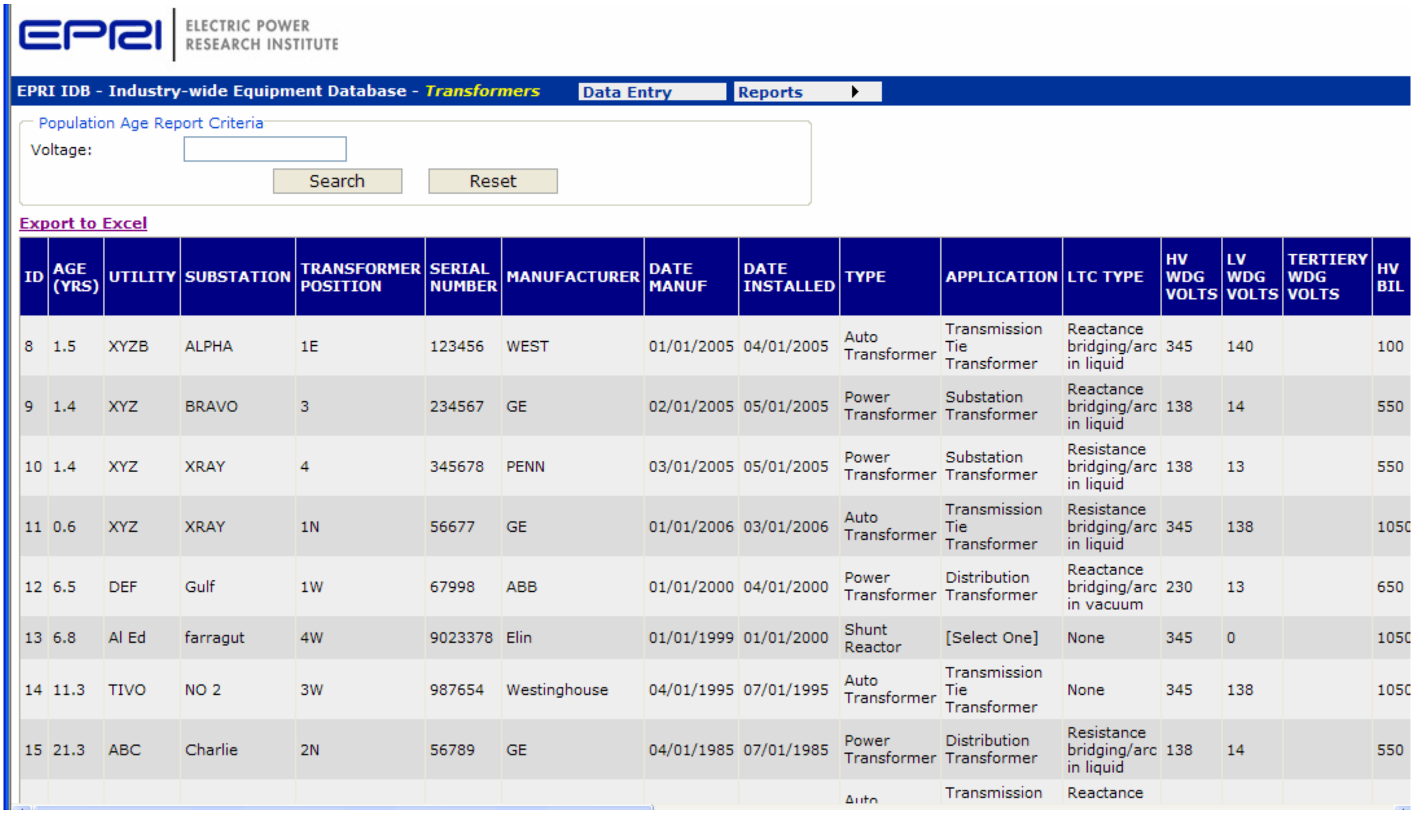
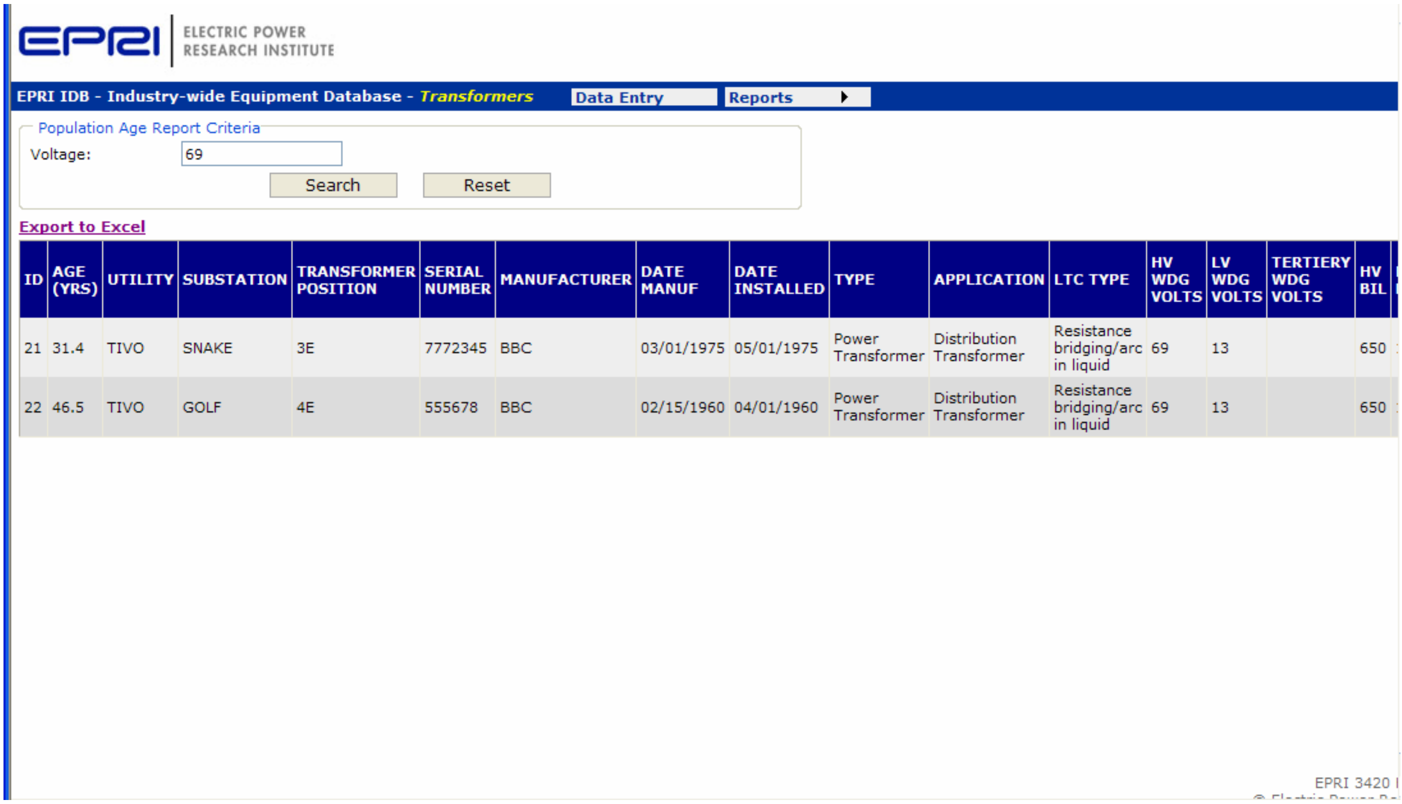


Figure 3-12
Report of the Entire Transformer Population by Age



ID	AGE (YRS)	UTILITY	SUBSTATION	TRANSFORMER POSITION	SERIAL NUMBER	MANUFACTURER	DATE MANUF	DATE INSTALLED	TYPE	APPLICATION	LTC TYPE	HV WDG VOLTS	LV WDG VOLTS	TERTIERY WDG VOLTS	HV BIL
8	1.5	XYZB	ALPHA	1E	123456	WEST	01/01/2005	04/01/2005	Auto Transformer	Transmission Tie Transformer	Reactance bridging/arc in liquid	345	140		100
9	1.4	XYZ	BRAVO	3	234567	GE	02/01/2005	05/01/2005	Power Transformer	Substation Transformer	Reactance bridging/arc in liquid	138	14		550
10	1.4	XYZ	XRAY	4	345678	PENN	03/01/2005	05/01/2005	Power Transformer	Substation Transformer	Resistance bridging/arc in liquid	138	13		550
11	0.6	XYZ	XRAY	1N	56677	GE	01/01/2006	03/01/2006	Auto Transformer	Transmission Tie Transformer	Resistance bridging/arc in liquid	345	138		1050
12	6.5	DEF	Gulf	1W	67998	ABB	01/01/2000	04/01/2000	Power Transformer	Distribution Transformer	Reactance bridging/arc in vacuum	230	13		650
13	6.8	Al Ed	farragut	4W	9023378	Elin	01/01/1999	01/01/2000	Shunt Reactor	[Select One]	None	345	0		1050
14	11.3	TIVO	NO 2	3W	987654	Westinghouse	04/01/1995	07/01/1995	Auto Transformer	Transmission Tie Transformer	None	345	138		1050
15	21.3	ABC	Charlie	2N	56789	GE	04/01/1985	07/01/1985	Power Transformer	Distribution Transformer	Resistance bridging/arc in liquid	138	14		550
									Auto	Transmission	Reactance				

Figure 3-13
Population Report by Voltage and Age and Specific Utility



ID	AGE (YRS)	UTILITY	SUBSTATION	TRANSFORMER POSITION	SERIAL NUMBER	MANUFACTURER	DATE MANUF	DATE INSTALLED	TYPE	APPLICATION	LTC TYPE	HV WDG VOLTS	LV WDG VOLTS	TERTIERY WDG VOLTS	HV BIL
21	31.4	TIVO	SNAKE	3E	7772345	BBC	03/01/1975	05/01/1975	Power Transformer	Distribution Transformer	Resistance bridging/arc in liquid	69	13		650
22	46.5	TIVO	GOLF	4E	555678	BBC	02/15/1960	04/01/1960	Power Transformer	Distribution Transformer	Resistance bridging/arc in liquid	69	13		650

Figure 3-14
Failure Report Indicating LTC Failures

4
IDB IMPLEMENTATION

Overview

The following diagram provides a high level overview of the IDB Implementation Architecture:

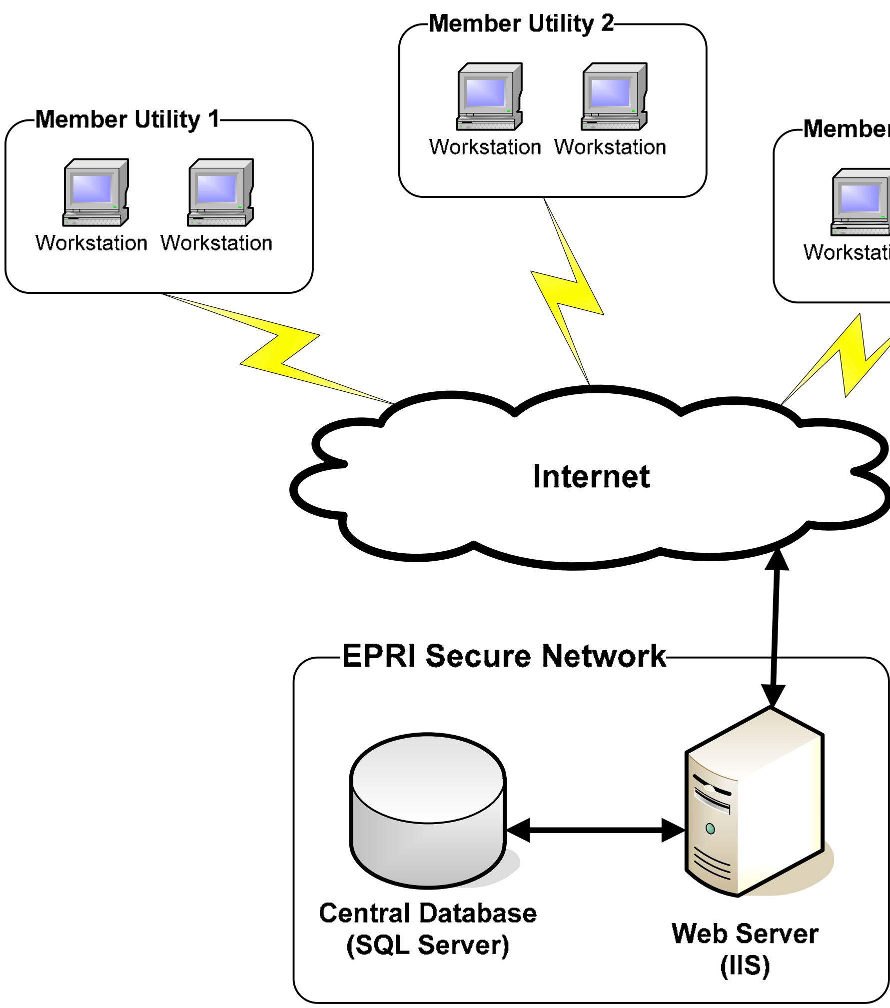


Figure 4-1
Overview – IDB Implementation Architecture

As shown above, the Transformer IDB (TIDB) system, which consists of front-end User Interface (UI) and back-end Database (DB), will be hosted in a secure environment within EPRI. The database will run on SQL Server while the UI of the application will be rendered via an

Internet Information Server (IIS), which is a component of Windows operating system. The member utilities will have access to the TIDB system via Internet. For security reasons, the system is designed to not allow a utility to have direct access to the database. All the communication between DB and the utility will be through the Web Server. If desired, the DB and the Web Server may be implemented on one server. The decision of whether to implement both DB and UI on the same server will depend on several factors (e.g. such as number of utilities signed up, complexity of the queries, number of users accessing the system simultaneously etc.) which are beyond the scope of this document.

Hardware and Software Requirements

It should be noted that the software and hardware requirements for any system are greatly affected by the number of users simultaneously accessing the system. Since at this point there is not enough visibility into the number of users, the information provided here should only be used as guideline.

The following table lists key software and hardware requirements related to the TIDB system.

Single Server Deployment – DB and Web Server on single computer

Name	***Licenses/Quantity***	***Software/Hardware***
Windows 2003 Enterprise Edition	1	Software
SQL Server 2005 Enterprise Edition	1	Software
Server w/ - Dual Processors, Pentium IV or Athlon - 2 GB RAM (min) - 200 GB HDD (min)	1	Hardware

Dual Server Deployment – DB and Web Server on two separate computers

Name	***Licenses/Quantity***	***Software/Hardware***
Windows 2003 Enterprise Edition	2	Software
SQL Server 2005 Enterprise Edition	1	Software
Web Sever - Single Processor, Pentium IV or Athlon - 1 GB RAM (min) - 40 GB HDD (min)	1	Hardware
Web Sever - Dual Processor, Pentium IV or Athlon - 4 GB RAM (min) - 200 GB HDD (min)	1	Hardware

Costs

The costs associated to this system can be classified into following two types:

- *Initial Investment* – This is a combination of expenses associated with, the development lifecycle (design, development, testing etc.) and the acquisition of required software licenses and hardware. The following table lists the estimated Initial Investment.

Single Server Deployment – DB and Web Server on single computer

Item	**Unit Cost**	**Qty**	**Total Cost/Item**
Development Lifecycle			
Windows 2003 Server Enterprise Edition		1	
SQL Server 2005 Enterprise Edition		1	
Server (h/w) - Dual Processors, Pentium IV or Athlon - 2 GB RAM (min) - 200 GB HDD (min)		1	
Total Cost			

Single Server Deployment – DB and Web Server on two separate computers

Item	**Unit Cost**	**Qty**	**Total Cost/Item**
Development Lifecycle			
Windows 2003 Server Enterprise Edition		2	
SQL Server 2005 Enterprise Edition		1	
Web Sever (h/w) - Single Processor, Pentium IV or Athlon - 1 GB RAM (min) - 40 GB HDD (min)		1	
DB Sever (h/w) - Dual Processor, Pentium IV or Athlon - 2 GB RAM (min) - 200 GB HDD (min)		1	

- *Maintenance Cost* – This is the cost incurred in maintaining the system (bug fixing, functionality enhancements etc.) after the deployment in production. This a variable cost that will greatly depend on the type of the work performed.

5 ARCHITECTURE SUMMARY

IDB Design Goals

- Open and modular architecture for step-by-step implementation
  - Secure, central database on EPRI server
- Different levels of access for company data and data of others
  - Can access detailed information only of own assets
- Templates with standard queries/reports for efficient analysis
- User-friendly data analysis tools for ad hoc queries
- Scheduled broadcast reports

Assumptions

- Each utility is different
- Not all data is currently available
- Data availability will improve overtime
- Focus is on power transformers
  - GSU
  - Transmission substations
  - Distribution substations
- Detailed data will be for internal utility use
- Screened data will be shared among utilities

Status

- Step by step approach
- Rapid development towards foundation
  - Excel and Access
- Concentrate on:
  - Ease of use
  - Data requirements and availability

6
CONCLUSIONS

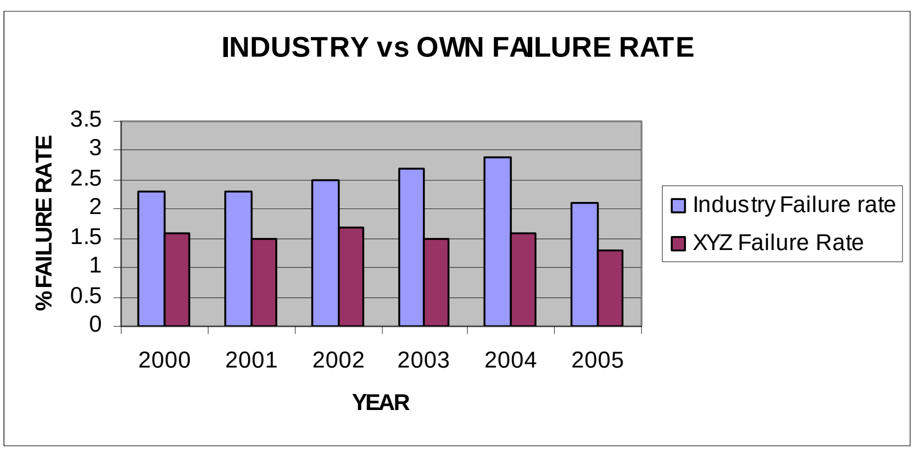
Asset management

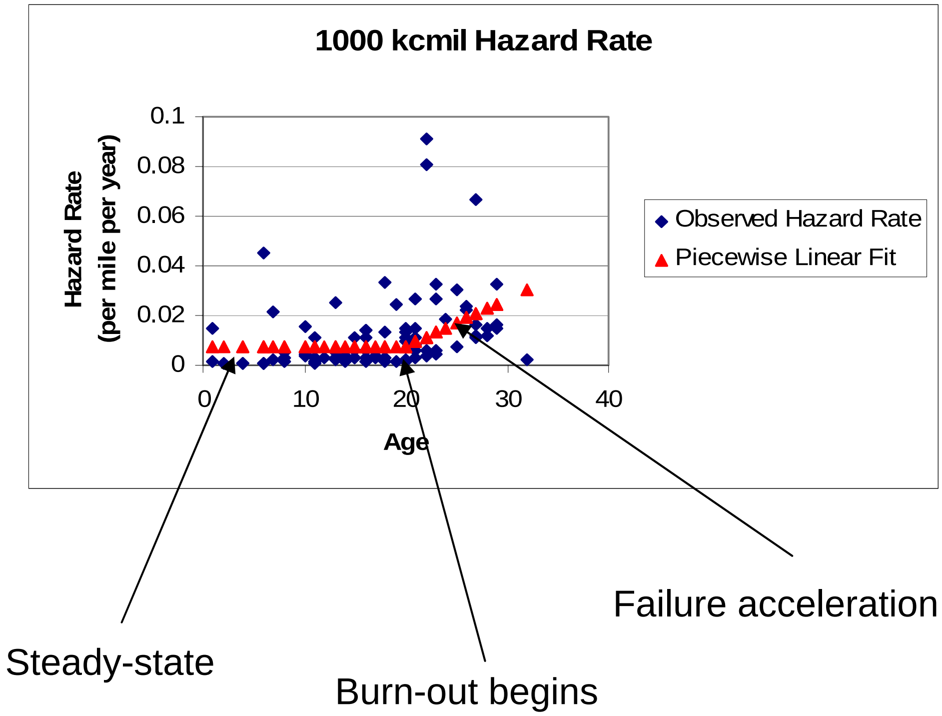
- Minimizes lifecycle-cost of equipment replacement and maintenance, including failure costs
- Risk Identification using Generic Transformer Failure Rates is no longer sufficient; required are failure descriptions based on Family, Make, Application, Age, Model and Application.
- The Industry Wide Equipment Performance Database will support multiple decisions:
  - Maintenance scheduling – what and when
    - Equipment failure models forecast condition degradation and failure rates
- Repair or replace decisions
  - Forecasts annual equipment budgets and failures

Near Term Research Vision

- Estimating Failure Rates using statistical analysis of large historical equipment performance data set
  - Develop equipment failure model
  - Fit to data
  - Calibrate models

Sample Analysis





- Inputs for developing Hazard Rate Curves
- Validate Life Expectancy Models

Long Term/Ultimate Research Vision

- Use the IDB as an analytical tool for asset planning:
- Develop algorithms, key performance indicators and equipment performance models for
  - Triggers &/or Alarms driven by Limits, Thresholds
  - Condition Indicators
  - Examples:
    - To Schedule an Outage
    - Initiate an Internal Inspection and follow-up Overhaul
    - Initiate Corrective Action
    - Rank Families of equipment

Interest Survey Results

- Consensus of 14 responses
  - Data entry mode – Batch and Internet
  - Main uses – Failure rate analysis by age, manufacturer, application; uncover design issues

– Population focus – 69 kV, 30 MVA and up

– Historical data – Go back 5 to 10 years

Database Potential: What Can the Database Do For the User?

Listed below are some of the potential uses of the Transformer- Industry Data Base.

A. What is the age profile of a utility's aging transformer population?

B. What is the age profile of all the transformers in the data base?

C. What is the serviceability record of a utility's LTC equipped transformers?

D. What is the industry wide serviceability record of the LTC equipped transformers?

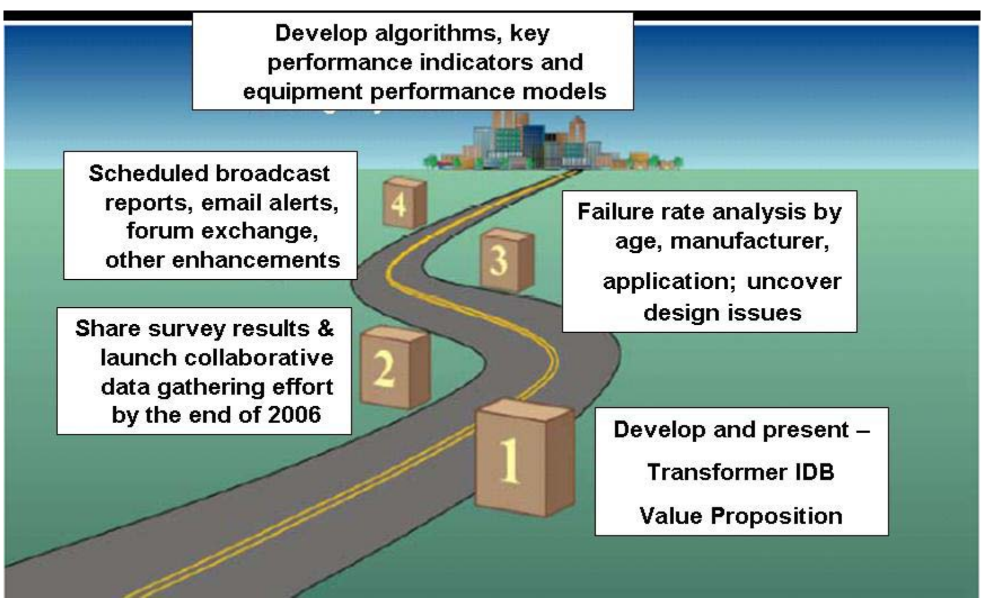
E. What is the industry failure rate of transformers by manufacturer?

F. By voltage ?

G. Those utilities who want to determine the adequacy of the spare transformers on their system could perform statistical analysis using their failure rate by application and the industry failure rate by the same application to determine an annual failure rate of transformers used in a particular application.

H. What are the common causes of failure in total transformer population?

IDB Road map Vision – Moving Forward



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