

## DEVELOPMENT OF COMPUTER-BASED FCDS INSPECTION REPORTS

Arnel V. Mejorada and Josephine E. de Castro

PNOC Energy Development Corporation, Merritt Road, Fort Bonifacio, Taguig, Philippines

### ABSTRACT

*The FCDS (Fluid Collection and Disposal System) application module is part of the Integrated Geochemistry Information System of PNOC-EDC's Geoscientific Department. The creation of the FCDS module was brought about by the introduction of the Risk Based Inspection (RBI) Methodology to the geothermal installations of PNOC-EDC.*

*The RBI method, together with the Asset Management System (AMS) showed the efficiency of a new means of inspection and maintenance of geothermal installations. The ultimate objective of the method is to ensure the availability of geothermal energy throughout the lifespan of the Fluid Collection and Disposal System (now referred to as FCRS for Fluid Collection and Reinjection System) of PNOC-EDC's geothermal fields despite the onset of age and associated wear and tear on the equipment.*

*The FCDS database was designed as a repository of data for geothermal pipelines, valves and separator inspections. Collating and analyzing the data provides valuable information for maintenance management. The information provides basis for determining preventive or remedial actions, prioritization of activities, and cost-benefit analyses of alternative methods.*

### 1.0 INTRODUCTION

The introduction of Risk Based Inspection (RBI) methods to the maintenance work system for geothermal facilities and installations has led to the creation of an additional module in the Integrated Geochemistry Information System (IGIS) of PNOC-EDC's Geoscientific Department, called the FCDS (Fluid Collection and Disposal System) application module.

Its database was designed as a repository for pipelines, valves and separator inspections data. These data are collated and analyzed to generate computer-based FCRS inspection reports, which are used to formulate/determine cost effective strategy and techniques.

### 2.0 RISK BASED INSPECTION

Risk based inspection is essentially a preventive maintenance system for predicting potential problems. Once these problems are identified and classified, remedial solutions are performed, thus preventing major disruption in operations.

This system is divided into 3 phases, namely phase 1: risk assessment, phase 2: condition assessment and phase 3: monitoring problem assessment.

The first phase is the data collection stage, where the structure, limitations (temperature and pressure) and plant designs of the geothermal vessels, brine, steam and condensate lines are catalogued. The internal environment of the pipes and vessels are characterized. The physical parameters measured, the chemistry of the fluids analyzed and the theoretical corrosion and scaling rate predicted.

With the maintenance history and evaluation of collated data, a life prediction risk profile is established.

The second phase is on condition assessment, where internal and external inspections are made on areas with high-risk profiles. Scale and corrosion samples are taken on these areas are analyzed. After which, an evaluation is made, risk assessment forwarded and the probable component failure predicted.

The third phase is monitoring and problem assessment. During this phase, re-inspections are made, the wall thickness, infrastructure

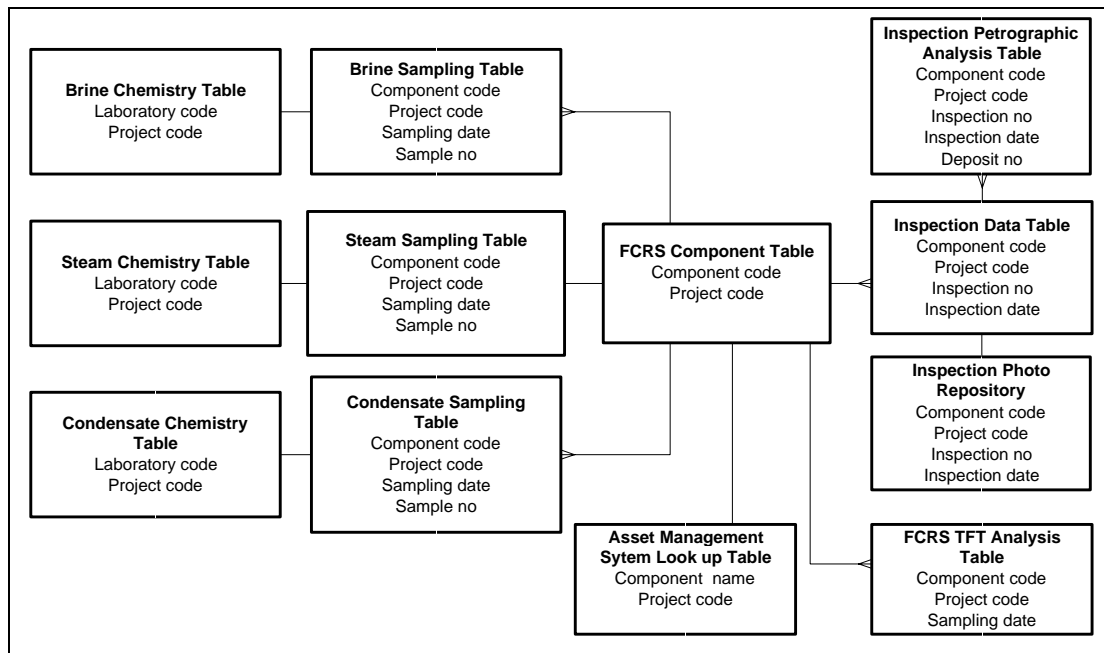


Figure 1. Entity-Relationship Diagram for the FCDS Database.

conditions, pressure, temperature, flow rate, chemistry changes are monitored and the risk assessments updated.

Based on these assessments, measures are then taken to ensure increased lifetime of the components

### 3.0 DEVELOPMENT OF THE FCDS MODULE

An FCDS database module was created to house the risk based inspection data for easy retrieval and processing. This module contains tables that are needed to accurately describe the internal and external conditions of the components of interest. Tables were created for the components data, brine, steam and condensate chemistry, inspection data, petrologic data, well output and flow-rates.

Storing these data in a precise format enables a database management system to turn the data into useful information through many types of output, such as queries and reports

The relationships of these tables are given in the entity-relationship diagram (Fig. 1). The description of the content each table is as follows:

- **FCRS COMPONENT TABLE** – The table that stores component name from the Process and Instrumentation Diagram with corresponding component code.
- **ASSET MANAGEMENT SYSTEM LOOKUP TABLE** – The table that stores data from the Process and Instrumentation Diagram as designed and as built from AMS.
- **BRINE SAMPLING TABLE** – The table that stores all brine sampling data from geothermal pipelines in the FCDS.
- **BRINE CHEMISTRY TABLE** – The table that stores all brine chemistry from geothermal pipelines in the FCDS.
- **STEAM SAMPLING TABLE** – The table that stores all steam sampling data from geothermal pipelines in the FCDS.
- **STEAM CHEMISTRY TABLE** – The table that stores all steam chemistry from geothermal pipelines in the FCDS.
- **CONDENSATE SAMPLING TABLE** – The table that stores all steam condensate sampling data after passing through the power plant.

The screenshot shows a Windows 95/NT application window titled "INSPECTOR". The window has a menu bar with "Action", "Edit", "Query", "Block", "Record", "Field", "Window", and "Help". Below the menu bar is a toolbar with various icons. The main area of the window is titled "INSPECTION DATA" and contains a form with the following fields and controls:

- Project Code (text input)
- Component Code (text input)
- Sector Name (text input)
- Location of Sampling (text input)
- Part Inspected (text input)
- Inspection Number (text input)
- Inspection Date (text input)
- Inspector Name (text input)
- Operating Condition (text input)
- Physical Environment (text input)
- Physical infrastructures (text input)
- Physical Deformation (text input)
- Scale present? (checkbox)
- Corrosion present? (checkbox)
- Scale sample collected? (checkbox)
- Corrosion sample collected? (checkbox)
- Sample Abundance (text input)
- Sample Color (text input)
- Sample Thickness (text input)
- Sample Structure (text input)
- Sample Texture (text input)
- Sample Composition (text input)
- Sample Hardness (text input)
- Sample Density (text input)
- Sample Homogeneity (text input)
- Inspection Remarks (text input)

At the bottom of the form, there are two buttons: "Upload Photo" and "Petro Analysis".

Figure 2. Data Input Form for Inspection Data

- **CONDENSATE CHEMISTRY TABLE** – The table that stores all condensate steam 4 plant
- **INSPECTION DATA TABLE** – The table that stores inspection data, including megascopic analysis.
- **INSPECTION PHOTO REPOSITORY** – The table that stores the inspection photo for all sites.
- **INSPECTION PETROGRAPHIC ANALYSIS TABLE** – The table that stores the physical and petrographic description of the samples.
- **FCRS TFT ANALYSIS TABLE** – The table that stores enthalpy, mass flows and steam flows.

Once the data to be stored are identified, forms were constructed for easy encoding, review and modification of data. Forms are graphic interfaces for viewing and updating values in the database. Input forms for the component information, brine, steam and condensate chemistry, inspection data, petrologic analysis and tracer flow test results were created.

A sample of the inspection input form is given in Figure 2. This form displays the inspection data such as the project or location, component codes (item of interest), physical environment and other related data needed for assessing the reliability of the component for continued usage.

To navigate through all the data, queries were created to retrieve only the desired parameters from the tables. The brine, steam and condensate chemistry that passes through a pipeline or component could be easily be queried for evaluation purposes.

The collated data can then printed or outputted through the screen. The reports that can be generated by the FCDS module are the Inspection reports, process chemistry reports (silica saturation indices, non-condensable gases, steam quality) and the well measurement reports (enthalpy, mass flows, output). An example of a FCDS generated Inspection report is given in Figure 3.

These reports are used in the risk based inspection assessment of the FCDS component. Based on the chemistry, the corrosion and


<b>DETAILED DESCRIPTION</b>		Inspection ID : PA2001-00011 Inspector : AVM Inspection Date : 2002-11-21
<b>Component Name :</b> RI318BRL24IS2 <b>Name of Part :</b> 24" RI 318 IS2		
<b>Operating Conditions:</b> Last inspected 1999, Intermittent use since August 2003		
<b>Mechanical Effects and Cracking</b> None observed.		
<b>Photograph</b>		
		
<b>Corrosion and Scaling</b> Abundant silica deposits 12.76 mm at midpoint of pipe Gray deposit overlain with silica gel colloidal deposition Banding present, signifying different stages of deposition Irregular shaped ridges, rough texture Inner wall highly corroded		
<b>Megascopic Analysis</b> 90% of sample consists of amorphous silica products. ,sand-like particles 105% pyritized chips (1 cm. In diameter)		
<b>Microscopic Analysis</b> Amorphous silica – 90%; magnetite – 5%; rock cuttings – 5%		

Figure 3. FCDS generated Inspection Report

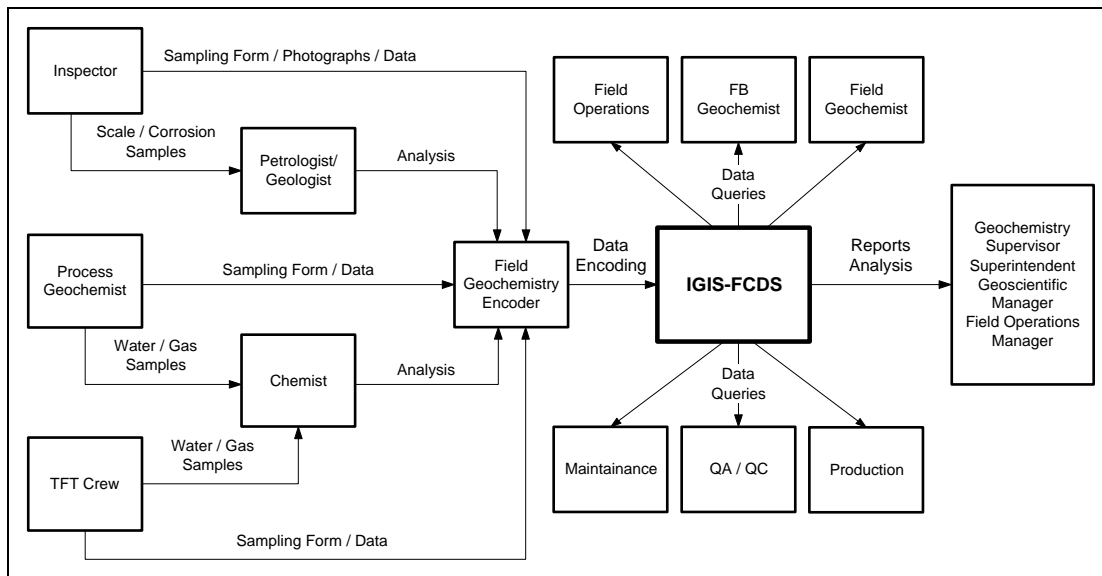


Figure 4. FCDS Data Flow Diagram

deposition rates can be predicted. Based on the inspections the actual rates are determined and the risk profile refined.

#### 4.0 DATA FLOW DIAGRAM

With the construction of FCDS database module, the processing of inspection and chemistry data are streamlined and the components with high risk of failure are easily determined and monitored. The flow of data to the FCDS module and its output can be summarized in Figure 4.

The sampling data from the Inspectors/samplers are given to the encoders for processing, the samples are given to the petrologist / chemist for analysis. The results of the analysis are then given to the encoders for encoding to the FCDS module. Once inputted, the data can then be viewed and evaluated by the geochemists, maintenance, production and quality assurance personnel and the reports and recommendations submitted to their superiors for action.

Using the snapshots capability of the Oracle database system, all project sites from different parts of the country are virtually linked and consolidated in the main office. Online status of the FCRS line as well as the inspection details could be viewed by decision makers in the head office through the interface provided by the

system. The overall snapshot design of the system is provided in Figure 5.

#### 5.0 CONCLUSION

The integration of FCDS application module with the RBI method and Asset Management System (AMS) would help ensure the availability of geothermal energy throughout the life span of the FCRS, despite the onset of material and equipment wear and tear associated with age.

The effectiveness of the database in determining the component lifespan depends on the quality and accuracy of the inputted data.

#### REFERENCES

Inspection, Documentation and Scale Sampling in FCRS and Power Plant, Geochemistry Procedures Manual, PNOC-EDC, unpublished manual.

Ramos, S.G., Rosell, J.B., Lichti, K.A., See, F.S, Fragata, J.J., Rubin, D.D., and Evangelista, R. (2003). Scaling and corrosion in separator vessel 303, BacMan geothermal production field, Philippines. Proceedings, 24<sup>th</sup> Annual PNOC-EDC Geothermal Conference, 173-182.

Prague, C.N. and Irwin, M.R. (2000). Microsoft® Access 2000 Bible, IDG Books Worldwide, Inc.

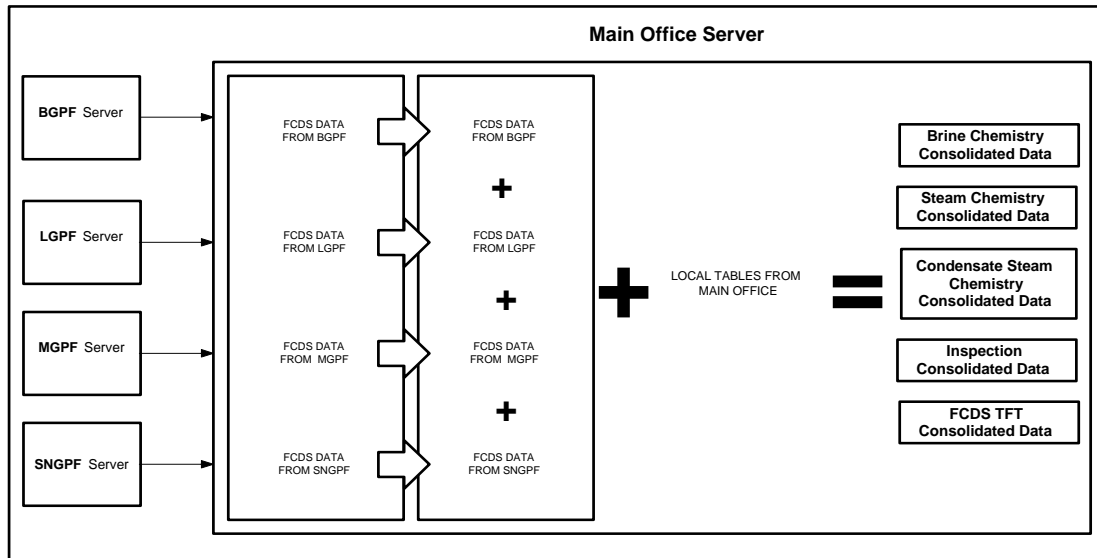


Figure 5. Snapshots Data Flow Diagram

Cowan, J.C. and Weintritt, D.J. (1976). Water-formed scale deposits. Gulf Publishing Company, Texas USA.

ASTM. (1993). Standard Practice for Recording Data from Atmospheric Corrosion Tests of Metallic-coated Steel Specimens. Annual Book of ASTM Standards, vol. 3.02.