WILLARD UNIT CO2 FLOOD - WELL SITE AUTOMATION SYSTEM

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ABSTRACT

This paper describes the automation system installed at the ARCO Permian operated, Willard Unit CO_2 flood. The automation includes a Supervisory Control and Data Acquisition (SCADA) system for pump off control, shutdowns and safety/environmental monitoring of over 300 rod pumped and flowing wells. The 24 hour monitoring system along with the data obtained, provides the benefit for identifying potential well problems and quick operator response. The paper also details the customization of the operator interface.

INTRODUCTION

The Willard Unit, operated by ARCO Permian is a tertiary recovery WAG (Water Alternate Gas-CO_2) flood located in the North Central portion of the Wasson San Andres Field, Yoakum County, Texas - Figures 1 and 2. The Unit was formed in 1964, and later enlarged in 1966 to encompass approximately 13,000 acres. The Unit was waterflooded until CO_2 injection was initiated in 1986 in the southern portion (Project Area) of the Unit. Currently the Unit consists of 321 rod pumped wells, 9 flowing wells, 240 WAG injection wells, 34 water injection wells, 13 test stations, one central battery, two water injection plants and the CO_2 recovery and compression plant.

Automation on the Unit has been installed in three stages. The first stage of automation in the Unit was the installation of automatic well testing at the Test Stations. This was followed by the next phase which included the installation of a Distributed Control System (DCS) for WAG injection well control. The third stage was the installation of a SCADA system for Pump Off Control on all rod pumped wells. This paper describes the automation system installed in 1992 for rod pumped wells to maximize profitability of the Unit, while significantly enhancing safety and environmental monitoring capabilities.

DISCUSSION

In 1992 ARCO decided to initiate field wide automation on all rod pumped wells. Pump Off Controllers (POCs) were installed on all Project Area wells. A total of 225 new POCs were installed and approximately 70 POCs were upgraded. A central four user computer network, capable of expansion to 12 nodes with one active hub was installed at the local office. The QNX® operating system was used due to its multi-user, multi-tasking, preemptive real time operating system capabilities. The QNX® windows platform provides for a Graphical User Interface (GUI) for the system. A SCADA platform with windows capabilities along with an application module for rod pump control and the module interface were installed. The system is capable of interfacing with most, commonly available RTUs and PLCs. The POCs communicate with the host system through a 450 MHz radio. The host computer continuously polls the remote POCs and reports any change of status or alarms.

The POCs were justified based on a 25% reduction in failures, a 20% reduction in power costs and a 2% production acceleration. AFIT economics of the project had a payout of 2.99 years and 39% investor's rate of return.

Along with the installation of POCs on all rod pumped wells, a consolidation of Pumpers and Engineering Technicians was initiated. The new job classification would provide the Production Technicians with the necessary tools for a more technical job that focused primarily on problem wells. The Production Technicians were trained in the operation of the POCs and its other functions such as electronic downhole pump valve checks, surface and downhole dynagraph analysis etc.

Installation, setup and commissioning of the POCs and host computer system required careful planning and scheduling. A decision on load cell configurations was made after field testing various load cell cables (fixed and snap-on) configurations prior to the installation. All load cells installed were mounted on the existing dynamometer plates above the carrier bar to enable better accuracy in load measurement. Installation of surge protection on the radio antennas also helped reduce electrical problems due to lightning damage.

Besides installation of the POCs, stuffing box leak detectors were installed on all wells. The stuffing box leak detectors, and existing high and low pressure switches were connected into the POCs. Stuffing box leaks are thus continuously monitored and the operator is capable of quick response to any potentially catastrophic environmental or safety conditions. Most wells in the Project Area are also equipped with a high performance butterfly safety shutdown valve at the well site actuated by the pressure switches through an electrohydraulic actuator. The POCs are also connected into the safety shutdown valves. Thus, status of the high and low pressure switches and safety shutdown valves are continuously monitored. This enables quick leak detection on flowlines or blocked/plugged lines or valves that could lead to unsafe conditions. The safety shutdown valves can be remotely actuated if required.

CRT Formats, Superkeys and Control Sequence Language (CSL) have been used to customize display screens to enhance user friendliness and for ease of operation. Individual database points, alarms, and corresponding alarm actions can also be defined.

Superkeys have been programmed for specific actions - such as the execution of all well site safety shutdowns associated with a particular test skid or a particular test station. The superkeys have the capability of globally shutting down either the safety valves and/or the pumping units, groups at a time. In the Willard Unit the groups are divided according to test skid and also test stations. The superkeys can be passworded at different levels to prevent any unauthorized actions. These features provide for immediate remote response to any problems or safety incidents.

CRT Formats, which are user configured displays, have also been built for ease of operation. A map of the Unit is divided by Test Station geographical boundaries encompassing all the associated wells. The status of the well symbol is color coded to allow for an operator to immediately see a change in status from normal (green) to either off-until-reset (red), software timer (yellow), or control transfer (purple). The well symbols are also used for initiating control actions to the POCs. Safety shutdown valve symbols are also featured on the map display by test station for sending valve shutdown commands to individual wells. Residents/Businesses within the boundaries of the Unit are also indicated on the map and information such as name, phone number and address are easily accessed by clicking (windows interface) on the appropriate residence through dynamic format links.

Various end devices can be used to help in individual well problems. These include pressure transmitters and vibration switches. Pressure transmitters are being tested to monitor flowline pressures not only for leak detection but also for trending pressures to determine when to hot oil flowlines. Analog signals such as pressure and runtime are also capable of being trended. User defined HI, HI-HI and LO, LO-LO can be assigned to the signals. The alarm actions can also be used to initiate automatic control through CSL. A vibration switch will be used to shutdown a pumping unit in a close proximity area where rod sticking has been a problem.

The alarm action processor will be used for automatic shutdown of wells on a particular Test Station if a Test Station shut-in has occurred. This prevents over-pressurization of flowlines and also protects for failure of pressure switches.

A couple of wells which had been converted to flowing wells from rod pump (due to the high volumes of gas produced) had the on on-site POC used as a Remote Terminal Unit (RTU) to monitor status of pressure switches and safety shutdown valves. These RTUs are also tied into the POC network. Pressure transmitters to monitor tubing/casing pressure can also be installed.

Customized reports combines data from the POCs such as daily runtimes, average runtime, maximum and minimum rod load data, and well test data from the DCS are used to calculate pump volumetric efficiencies, load ratio and load span numbers. The calculated values are flagged when they deviate from a user defined value. This enables quick identification of problem wells and potential problem wells.

Additionally, a laptop was also configured and set up with dial-up capabilities into the host computer system. This enables the user to remotely acknowledge alarms, check on individual wells, or shutdown wells remotely.

CONCLUSION

The automation has proven to have both tangible and intangible benefits. The following are some of the benefits realized with the automation system.

1. Resultant lower operating cost through lower utility cost. Electric power consumption on the Willard Unit has decreased approximately 13% from 3.1 MM KWH/month to 2.7 MM KWH/month. A large portion of this decrease in electric consumption is attributed to fine tuning of POC idle time and runtimes.
2. Reduced failure frequency. Failure frequency has dropped sharply by approximately 45%.
3. Maximized production due to reduced downtime and pumped off wells. CO_2 response has made it difficult to accurately determine any production acceleration due to the automation.
4. High Environmental and Safety Performance/Standards due to quick identification and response to problems
5. 24 hour monitoring through user friendly system with flexibility and capability of future expansion

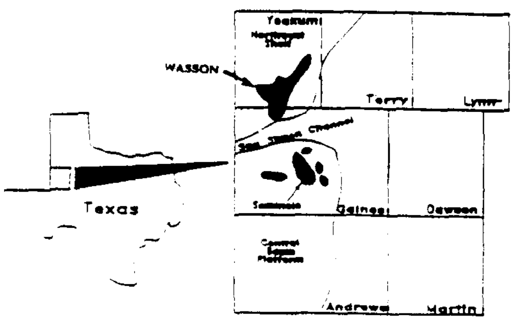

Figure 1 - Wasson Field Location

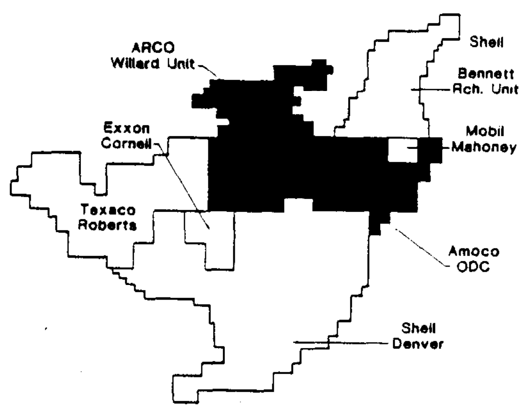

Figure 2 - Wasson San Andres Field, Yoakum County, Texas
Enhanced Recovery Units