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POV

End-to-End **Automation of Injection Control** – Think the BIG picture

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Abstract

Digitization is in the DNA of most of the information technology champions. The major gap in providing digital solutions is that the solutions are more IT-centric than focusing on helping or improving the business processes. This point of view may be very specific to the upstream sector in the oil and gas industry; however, irrespective of any business functions, it is vital to understand the business processes from the source it originates to its endpoints. As an IT enabling team, you will be involved in a very particular scope of service, but it is crucial to understand the end-to-end workflow to provide better solutions.

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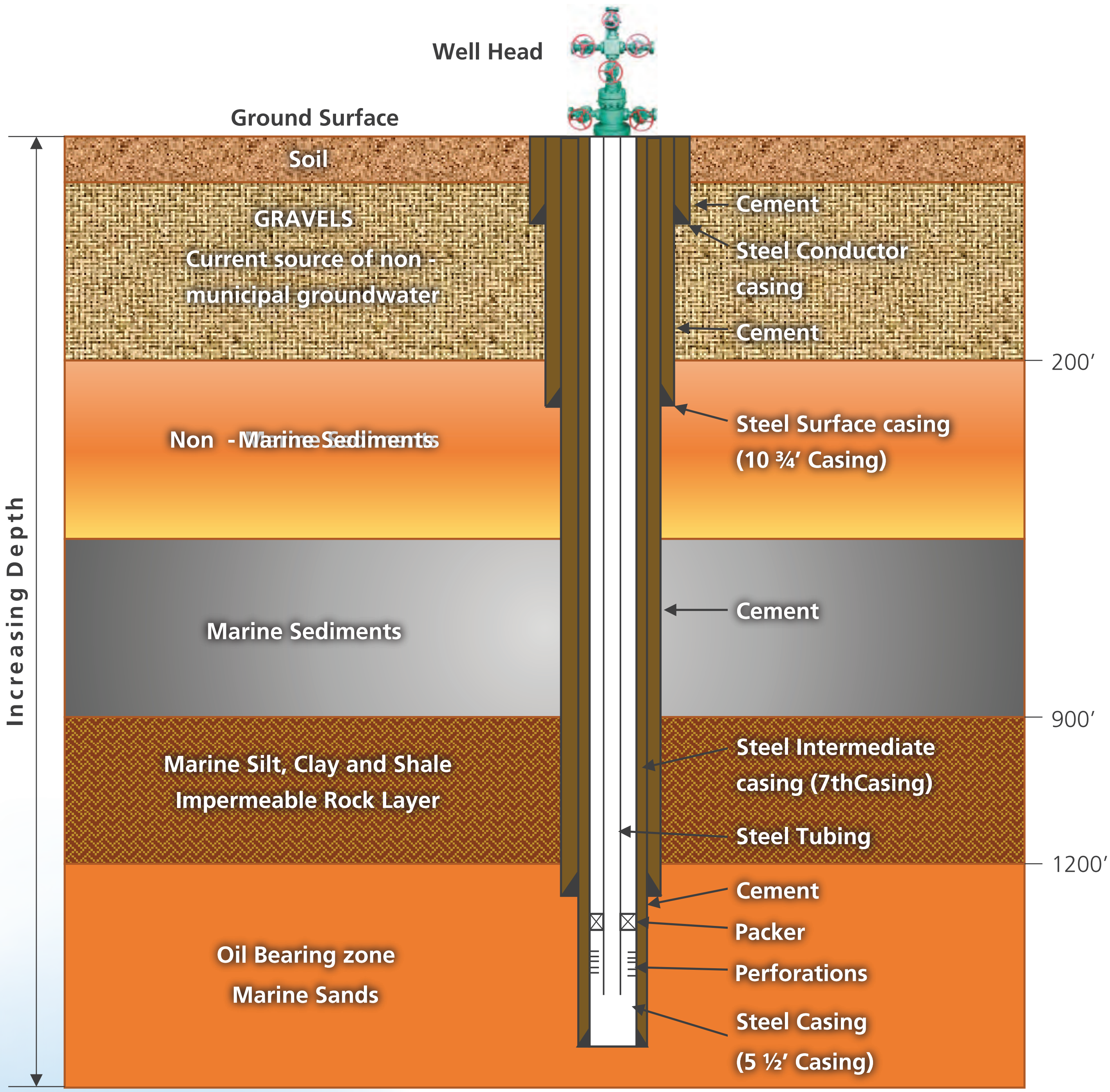
Preface

The primary well type used in the oil exploration and production sectors include production wells and injection wells. In this topic, we will be focusing on automation of injection control.

In the oil well fields, injection wells are inevitable to inject water, gas, steam, and/or fluids for enhanced oil recovery. After a permit is approved from the regulatory bodies to drill a new well, a deep hole around 4500 to 5500 feet will be drilled with the help of oil rigs. After this stage, a steel pipe is cemented in the hole; this layer is referred to as the casing. The casing prevents fluids in different zones from mixing. The layer will be perforated in the opposite direction of the injection zone. A tubing (usually a smaller diameter than the casing) is placed above the perforations with a packer (a sealing device that isolates fluids). Packers are used near the bottom of the tubing to seal it against the casing*. This sealing device prevents fluids from entering the space between the tubing and casing when it is injected down the tubing*. Periodic tests are needed to ensure the wells are running as expected and the injected fluids are confined to the intended injection zone*.

The industry also uses wells, called cyclic steam injectors. In the case of cyclic injectors, which are part of the thermal oil recovery process, the well is used to inject steam and then back into production*. A cyclic steam injection process includes the injection stage, during which steam is introduced into the reservoir; the soak stage, which requires that the well be shut in for several days for the equal distribution of heat; finally, during the last phase, the oil and condensed water are pumped out through the same well. This cycle is repeated.



General injection well

Image source- https://www.conservation.ca.gov/calgem

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Key factors to be considered during automation injection control

During the injection process, permitted fluids are injected into a well. The fluid pressure may vary based on the fluid type, flow, temperature, etc. Below are the factors that need to be monitored before injecting any fluid under the surface into the well.

- Identify potential leaks in the construction of the well
- Continuous pressure monitoring of the well
- Automatically cease injection when there is a risk to safety to the environment
- Groundwater or freshwater contamination running close (300 to 500 feet radius) to any injector wells - It is required to prevent the degradation of underground sources of drinking water (aquifers) where there are injection operations.
- Surface oil or any hazardous fluid Seep – To give importance to this factor, in 2011, an oil industry employee died tragically when the ground beneath him gave way, and he fell into a pool of heated fluid*
- Required maintenance of nearby wells
- Communication to the offset operators for the injection wells close to the lease line for further actions
- Submission of audit reports to the regulatory bodies on the well performance to avoid any notice of violations

Joining together all the above pieces

While all the key monitoring factors have to be maintained, it is crucial to continuously check the injection well performance and take necessary actions before it creates any hazard to the environment. Below are the critical points to be completed to cover the entire workflow:

Reconciling the list of injection wells operated by an organization across multiple assets; will be the first step toward continuous monitoring.

Satellite view of all the injection wells operated by the organization with the lease line. The map should also have the closest injection wells to the lease line.

Decide the data points required to be monitored along with the frequency.

Clear communication plan within the organization, regulatory bodies, and the offset operators.

Categorize the injection wells based on the location and the fluid type. This categorization is critical since based on the well's geological location and fluid type the data points to be monitored will vary.

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End-to-end digital solution

IT solution architects should aim to build a robust and flexible solution as the environmental and regulatory requirements change over time and adapt to the changing digital landscape.

What is a good look like?

It is always the biggest challenge to define the accepted data. For example, the sound data indicates how much fluid pressure is good to be injected into the well. This question is not at all a simple one; there are a sizable number of ways available to calculate the allowable pressure. This also depends on the fluid type, state, federal regulations, etc. IT needs to work with the well operations SMEs to align the calculations.
In this topic, we are not going to cover the right way to calculate the maximum allowable pressure for a well; rather I would be providing the below list of pointers to be considered while deriving the value. The fixed or static set point value for maximum allowable pressure should be avoided.

- Directional Survey
- Casing Depth
- Tubing Depth
- Perforation details
- Vertical depth
- True Vertical Depth
- Lease details
- Permit details
- Packer cup details
- Injection gradient
- Injection fluid gradient
- Fluid type
- Fluid quality
- Fluid temperature
- Safety factor

The endorsed data and the logic needed to derive the value will be maintained in an organizational endorsed DataMart for further consumption.

Well level instrumentations and time series data archive tools

With the data points required to be monitored, identifying the instrumentations and the scanners required to read the values continuously from the injectors should be an essential step to be carried away. IIoT architects should be involved in this phase to recommend the potential solution to capture and control the instrument data and the ways to historize the time series data that the business users can easily consume.
The decision of sensors should also be considered by how the communication is tracked. In case of no communication from the instrument, sensor battery power with low voltage, and power disruption in the field are a few factors which affect the communication. The architects should keep an eye on all these external factors affecting communication and recommend appropriate solutions.

The power of data archive and real-time data management tools to be explored to adequately capture, process, analyze and store the real-time data. Below are a few points to consider while deciding on the right time series data tools from the market.

- Data scalability
- Support to view data in different formats
- Performance
- Support
- Ability to enable notifications through email or text messages
- Ability to communicate with external systems
- Ability to trigger events and end events in case of any irregularities
- Ease of use
- Security
- Cloud Readiness

Updated satellite data with well-details

It is always a challenge to have the updated satellite data with the lease line to understand the scope of injection wells and the water wells. Finding the right source requires extended help from the organization "Health Environmental and Safety" or other teams to connect with the approved record system. There is no need to reinvent the wheel, the data can be consumed by an approved API (Application Programming Interface) endpoints from the recommended sources. Once identified, tagging the injectors are closer to other injector wells, closer to water wells, and closer to any offset operated wells should be done and stored in an endorsed DataMart which can be easily consumed by other applications/tools.

During any injection activities, it is mandated to let the internal team and the offset team be aware of the injection plan so that the required actions can be taken to any nearby wells. Below are the critical factors to be defined while setting up the entire process.

- Make sure the nearby wells are calculated not just based on surface latitude and longitudinal data but also with the bottom hole coordinates
- Frequency of the fluid injection plan to be shared
- Ways of transferring data – Utilizing cloud services, APIs, secured file transfer protocols, etc.,
- Defined actions needed in the nearby wells

The identified method will also help to establish an automated way of sending out reports to the regulatory bodies about the injection well performance.

Post Event - manual vs. automated actions to control

The decision of manual or automated actions to be done based on the events relies on the following factors:

- Availability of any existing tools to create workflows for the engineers in the field to do the manual operations in the well
- Reliable Supervisory control and data acquisition (SCADA) control devices and time series data tools
- Time to act in case of any events

- **Manual Approach**

  The time series tool selected should have the capability to communicate with external systems and create a required entry. In all major oil and gas companies, a well reliable and operational tool should already be in place. In case of events in the well, like the injected fluid pressure going beyond the maximum permitted pressure, an event should be triggered. Notifications should be enabled to alarm the field engineers on their mobile devices, email to the entire operation team, and make an entry in the existing well-reliable tool. The tool should be capable of automatically closing the events once the event is resumed to its normal state.

- **Automated Approach**

  In case of any occurrence of an event, as explained in the above section, we can unleash the full power of SCADA controls to take control of the instrumentations in the field and do necessary actions like shutting down the well, reducing the pressure set point value, adjusting the orifice plate, reducing the flow, controlling the turbines or any other sources which are producing the injected fluid, etc., This will enable the full automation of injection wells controls. Reliable communication between SCADA controls and the instrumentation in the field is a crucial decision maker. In case of any events, the SCADA controls can execute the required scripts to take corrective actions directly from the office instead of physically getting into the field.

  In both cases, a sizable number of benefits are achieved to maintain the regulatory requirements and ensure the right actions are taken at the right time.

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Conclusion

The approach toward thinking about the big picture is vital in any program. Here the workflow is highly critical to run the oil well as it may lead to the cancellation of the license to operate in case of any events. Applying a digital solution will solve the manual effort and ensure the actions are taken on time. It is required to unleash the full power of all digital solutions, execute a detailed decision analysis exercise, select the right tools and technologies, enable proper communication channels, and include the non-functional (in this case, reduction of manual interventions, automated communications, etc.) use cases as part of the program scope and finally to select the right model for the program execution for a successful program. Architects should review the end-to-end workflow from the business point of view and map it to the vast technology stack available in the market to meet the ever-evolving digital world.

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Reference

*https://www.conservation.ca.gov/calgem

About the Author

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Sarath has 19+ years of experience in the Information Technology with 6 years in the Oil & Gas Industry. He is a PMP and Agile certified professional and currently a DevOps lead responsible in managing IT solutions for one of the major American multinational energy corporations. He has experience in program management, delivery excellence through lean and agile methodologies, DevOps, cloud computing, client relationship management, people management and change management. Sarath brings strong domain, process, and technology background with focus on delivering tangible results.