

Predict® 7.1

Product Information Note

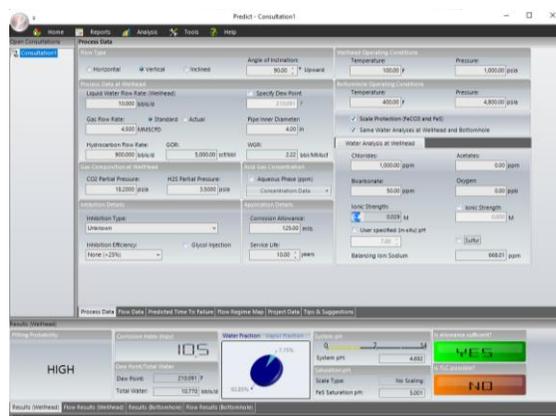
Accurate Corrosion Prediction for Carbon Steel in Multiphase Oil & Gas Production or Transmission Systems: Predict® 7.1 is the latest update to the industry-leading corrosion prediction software suite with new features. Predict now includes Top of the Line Corrosion and Sand Erosion Models.

CO₂ and H₂S corrosion (termed acid gas corrosion) in oil and gas production environments are key contributors to asset degradation and failure. Sand erosion and Top of the Line Corrosion are two other damage mechanisms that adversely impact asset life. Accurate quantification of corrosion and erosion is critical in enabling improved assurance in safe utilization of steels in almost every production unit in oil and gas production and transmission.

Honeywell's Predict software takes an integrated, comprehensive perspective to intelligently assess system corrosivity and facilitates prediction of corrosion and erosion rates for carbon steels in production / transmission environments containing CO₂ and/or H₂S. Based on decades of joint Industry Program research and industry utilization data, Predict captures the effects of key critical environmental and operating parameters that influence corrosivity. It further characterizes the effects of these parameters on corrosion rates, utilizing extensive laboratory data, phase behavior models and fluid dynamic characterization.

Damage Assessment Made Easy

Predict offers an intuitive user interface that takes little time to master and delivers results quickly. The user interface presents pertinent inputs needed to quantify the relevant production or transmission environment variables. These inputs are commonly available design, environmental and operating factors. The calculated damage rate results are then displayed.



Predict main program interface, showing predicted carbon steel corrosion rate, pitting corrosion likelihood and other relevant results

FEATURES & BENEFITS

- **Benefits:**
 - Reduced Chemical Inhibitor Expenditures
 - Improved Reliability and Maintenance Programs
 - Optimized metallurgy selection for assets
 - Improved Safety and Reliability
- **New Features:**
 - Sand and Particulate Erosion Model
 - Top of the Line Corrosion Model
 - Pure Water Oxygen Corrosion
 - Flow Regime Map: Quickly and visually assess stability of flow pattern
- **Improved Features:**
 - New and more accurate flow model
 - Improved Multi Point Sensitivity Analysis tools to help identify safe operating envelopes
 - Improved rules to account for variation of water content in oil and gas systems
- **Features:**
 - Predict carbon steel corrosion rates in various acid gases environments
 - Use gaseous or aqueous CO₂ / H₂S concentration data
 - Predict corrosive effects of systems with chlorides, oxygen or sulfur
- **Characterize water phase behavior from specified dew point with/without glycol**
- **Evaluate the effectiveness of Corrosion Inhibitors**
- **Evaluate entire pipeline or well profiles with horizontal, vertical or inclined segments**

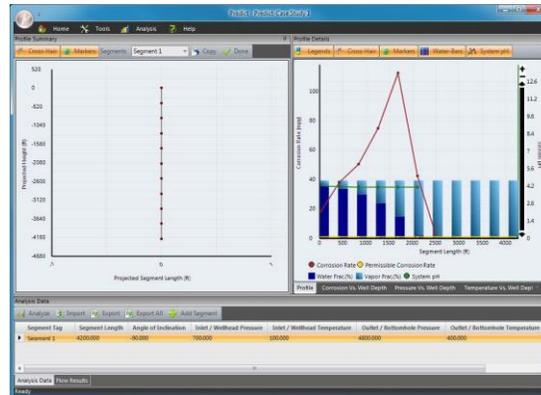
Corrosion and Erosion Prediction

Predict provides a practical system for evaluating corrosion and erosion for carbon steel based on available operational parameters. This enables informed financial and engineering decisions built on real material performance data. The different models embedded within Predict offers several unique features:

- Extensive, data-driven CO₂/H₂S corrosion prediction model incorporating all the relevant component effects in multiphase oil/gas systems
- An accurate ionic model for pH computation accounts for the effects of 16 different anion and cation species,
- Rigorous water phase behavior calculations coupled with the ability to account for the effects of glycol (MEG, TEG and DEG)
- Ability to accurately model momentum transfer effects (flow regimes, void fractions, pressure drops and shear stresses)
- Ability to accurately determine scaling effects due to formation of iron carbonate and iron sulfide scales as a function of temperature and pH
- Improved rules to account for variation of water content in oil and gas systems (production and transmission)
- Perform advanced flow modeling and correlate wall shear stress effects on corrosion rate from JIP data
- Perform life cycle cost analysis and graphically view of service life of pipe from predicted time to failure plot

In addition, a multiphase Flow Model enables the user to visualize the flow regime and evaluate the effects of flow occurring in a particular section of a pipe. Applicable to inclined flows for both uphill and downhill flow, the Flow Modeling feature can calculate a two-phase Reynolds Number, a

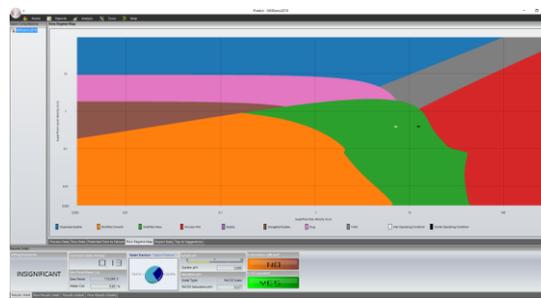
friction factor, and accounts for effects of liquid hold-up and wall shear stress on predicted corrosion rates. Predict incorporates both the environmental (electrochemical) and fluid dynamic parametric effects on corrosion.



Evaluate pipeline corrosion rates between inlet and outlet or well corrosion profile between bottomhole and wellhead

Predict offers several unique tools to enable the user to evaluate the impact of operating variables:

- Corrosion profile: Evaluate entire pipeline profiles with horizontal, vertical or inclined segments between pipeline inlet and outlet or well bottomhole and wellhead.
- Flow Regime Map: evaluate flow regime stability by locating operating conditions on a map of flow patterns
- Perform Sensitivity Analyses: Multi-Point Sensitivity Analyses and Expert Multi-Point Sensitivity Analyses enable the user to identify safe operating envelopes by vary one or multiple variable and see their impact on corrosion/erosion rates.



Flow Regime Map – Assess the stability of the flow pattern



Expert Multi-Point Sensitivity Analyses – Quickly identify the full range of corrosion rates with varying operating conditions

- Perform Multi-Point Analyses: quickly assess multiple locations by importing data from excel spreadsheets

CO₂ and H₂S Corrosion Prediction

Predict provides a practical prediction of system corrosivity for carbon steel based on available operational parameters such as:

- Application or process data (pressure, temperature, gas oil and water flow rates)
- Speciation data (acid gas concentration and water analyses)
- Project data (service life, corrosion allowance, well or stream information)

Once the input data is entered, Predict outputs the following corrosion and water characteristics:

- Predicted corrosion rate, expressed in mpy or mmpy
- Pitting probability
- In-situ pH
- A computed system dew point and water phase distribution
- Quantification of liquid water
- Scaling products and saturation pH

Predict offers several unique attributes:

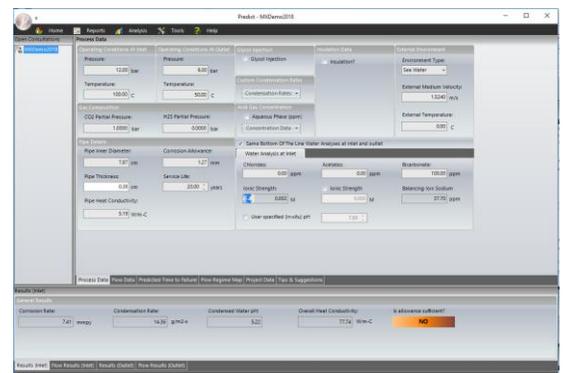
- A corrosion prediction system to provide a way to estimate probability of pitting corrosion

- Ability to accurately characterize role of oxygen concentration in corrosive systems
- Perform prediction from gaseous or aqueous CO₂ / H₂S corrosion data
- Characterize water phase behavior from, liquid water flow or from a specified dew point
- Quick access to actual laboratory test data encompassing over 18 flow loop tests
- Accurately determine scaling effects due to formation of iron carbonate and iron sulfide
- Predict corrosive effects of systems with chlorides, oxygen or sulfur

The impact of key variables on general corrosion can be rapidly evaluated through sensitivity analyses, multi-point analyses and expert multi-point sensitivity analyses.

CO₂ Top of the Line Corrosion

Research efforts undertaken in various research institutes and companies have shed some lights on the mechanisms and key factors governing Top of the Line Corrosion (TLC) in CO₂ environments. Predict now includes these insights and makes TLC assessment a simple task.



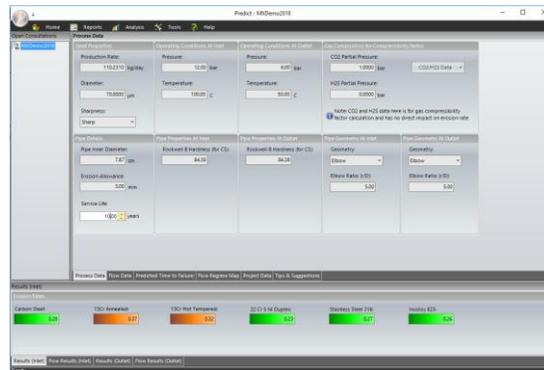
Top of the Line Corrosion – evaluate TLC corrosion rate, condensation rate and condensed water pH as a function of operating conditions.

Predict provides a practical system to evaluate Top of the Line Corrosion for carbon steel based

on available operational parameters such as:

- Application or process data (pressure, temperature, gas oil and water flow rates, use of glycol)
- Speciation data (acid gas concentration and water analyses)
- External environment and design data (External environment temperature, presence and type of insulation, condensation rate)
- Project data (service life, corrosion allowance, pipeline information)

- Pipe properties and geometry (elbow, tee, choke, impingement, straight)
- Project data (service life, erosion allowance, pipeline information)



Once the input data is entered, Predict outputs the following key results:

- Predicted corrosion rate, expressed in mpy or mmpy
- Water condensation rate
- Condensed water in-situ pH

The impact of key variables on TLC can be rapidly evaluated through sensitivity analyses, multi-point analyses and expert multi-point sensitivity analyses.

Sand Erosion

Erosion has been well recognized by oil and gas industry as one of the main threats to the integrity of onshore and offshore facilities that carry high flow hydrocarbon mixtures. Of the different types of erosion, sand erosion attracts the most attention since sands are commonly produced along with production fluids (oil, water and gas).

Predict provides a practical system for evaluating sand erosion in oil and gas production systems based on operational data:

- Application or process data (pressure, temperature, gas oil and water flow rates)
- Produced sand characteristics data (sand production rate, diameter, sharpness)

Sand Erosion – Evaluate sand erosion rates for oil and gas production systems for carbon steels and 5 other steels.

Once the input data is entered, Predict outputs the following key sand erosion results:

- Predicted erosion rate, expressed in mpy or mmpy, for carbon steel and 5 CRA materials: 13Cr (annealed and hot tempered), Duplex 2205, 316 SS and Incoloy 825
- Sand loading (Weight %)

The impact of Sand Production Rate, Sand Diameter and other key operating variables can rapidly be evaluated through sensitivity analyses, and multi-point analyses.

Predict-RT: Real-time Corrosion Management

The corrosion prediction models available in Predict are also available for real-time corrosion prediction.

For more information on Predict-RT, refer to the Predict-RT Product Information Note.

Building a Standard Work Process for Corrosion and Erosion Prediction

The use of a modeling application like Predict allows a company or site to evaluate corrosion and erosion problems consistently and with high accuracy and repeatability. Predict is built upon a multi-faceted, foundation of corrosion and erosion knowledge, including proprietary data from hundreds of laboratory tests that constituted a Joint Industry Project (JIP) on Multiphase CO₂/H₂S corrosion extensive literature information, accurate multiphase flow modeling and the industry's most comprehensive database on steel corrosion rates.

Because corrosion in multiphase CO₂ and H₂S systems is an extremely complex phenomenon, the only way to model corrosion is to utilize laboratory test data generated under simulated flowing conditions. The JIP corrosion test conditions incorporate simulated flowing conditions and that data helps in formulation of rules correlating critical parametric relationships. Predict also incorporates rigorous mechanistic models for phase behavior, ionic analyses and flow modeling. This integration of first principles and real engineering data provides Predict the unique foundation to accurately predict corrosion and erosion under a wide range of operating conditions relevant to oil and gas production and transmission systems. The result is that Predict is the only system available today whose numerical model is built upon real H₂S and CO₂ corrosion laboratory testing data integrated with rigorous flow and ionic modeling.

The Predict model also captures the individual and synergistic effects of critical parameters on corrosion rates. The primary environmental variables found to influence corrosivity are those which contribute to acidic pH in production environments (the acid gases, CO₂ and H₂S). Predict uses the system pH as a central factor in modeling mechanisms that contribute significantly to corrosivity, including the roles of multiple anions and cations, as well as assessing the role of pH in the dissolution and/or precipitation of corrosion product. The inclusion of these fundamental determinates is factored

into the output from Predict, which also includes a separate Sensitivity Analysis function allowing the user to see the effect of individual factors like acid gases, acetates and production rates on the predicted pH and corrosion rates.

With an underlying foundation based upon real corrosion research and first principles, Predict uses a practical approach to modeling corrosivity:

- First, provide a predictive model that utilizes commonly available environment and operating parameters
- Second, utilize existing lab data, field data, or theoretical models to obtain realistic assessments of corrosivity and corrosion rates
- Third, include a computational approach that integrates both numerical and heuristic (field data and experience) information and knowledge about corrosivity prediction

Most other predictive models tend to be either very conservative in their interpretation of results or focused on a narrow range of parametric effects; these approaches do not lend themselves to a practical application for predicting corrosivity or corrosion rates for oil and gas field applications where the ability to characterize effects of all the relevant parameters has to be complemented by an accurate basis for doing so.

With the foundation in place and confidence in an application built upon rigorous corrosion principles and data, users have built their standard working practice for corrosion and erosion prediction on Predict.

Honeywell Predict® Corrosion Suite

Honeywell Predict Corrosion Suite provides next generation corrosion management solution for oil and gas and refining industries seeking to move from reacting to corrosion damage to a more proactive and effective approach. Honeywell Predict® Corrosion Suite provides the next generation of corrosion management solutions. Unlike conventional corrosion management methods, we employ unique prediction models that encapsulate deep expertise and extensive process data to correlate corrosion rates to specific process units, damage mechanisms, and operating conditions. Using Honeywell's tools, global major companies have achieved significant operational and business benefits.

The Honeywell Predict Corrosion Suite is a unique solution for today's industrial facilities, driving a paradigm shift in tackling difficult corrosion problems, and enabling efficient and safe operations. These software tools help users move away from a reactive response to corrosion based on qualitative, manual inspections, to a proactive, reliability-centric predictive approach based on quantitative information from soft sensors, sound process deviation management, and "what-if" scenario analysis tools.

Why Honeywell?

Your operation can benefit from partnering with a proven leader in corrosion asset integrity and preventive/predictive corrosion management. Honeywell has extensive intellectual property in the corrosion field, including unique corrosion prediction and material selection models, and patented corrosion monitoring technology. Our deep expertise includes an in-house team of experts with decades of experience in developing corrosion solutions. Honeywell's IP-based models are licensed and used by many global oil & gas majors, and our company has a recognized track record of world-class execution of projects.

Honeywell has also established a unique corrosion knowledge community through our Center of Excellence (COE). We assist customers with expert local and remote support. Our state-of-the-art corrosion and materials research and engineering laboratory provides a host of standard and tailored services. Utilized in Joint Industry Programs and customized testing, this facility can simulate any service environment.

For More Information

Learn more about Honeywell's Corrosion Solutions, visit www.honeywellprocess.com/Corrosion or contact your Honeywell Account Manager, Distributor or System Integrator.

Honeywell Process Solutions

1250 West Sam Houston Parkway South
Houston, TX 77042

Honeywell House, Skimped Hill Lane Bracknell,
Berkshire, England RG12 1EB UK

Building #1, 555 Huanke Road, Zhangjiang Hi-Tech Industrial Park, Pudong New Area, Shanghai 201203

www.honeywellprocess.com/corrosion
predict@honeywell.com

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