About the Authors

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FEA Based Corrosion Processing To Minimize Steel Renewal

BY FRITZ WALDORF & ARNOLD BALSTER

Every FPSO and FSO vessel will reach a point in its lifecycle where there is a need for conducting corrosion analysis. Obvious reasons for such analysis are for life-extension purposes, as well as protecting the feasibility and class approval of the hull structure. Such work can be conducted on both new builds as well as conversions, especially when the work done at conversion was not extensive enough. The distressed oil prices our current market presents, requires vessel owners and operators to focus on efficiency in every aspect of their operations. SAGA, Viking System's structural assessment software, consists of a highly specialized 3D modeling tool that has assisted in confronting the issue of corrosion and asset integrity for floating structures. The method and software tools within SAGA have been developed for the processing of standard gauging reports to identify and visualize the location as well as the extent and severity of excessive corrosion. The structural processing and optimization process is used to minimize the extent of any required steel renewal, proving extreme savings in expense.

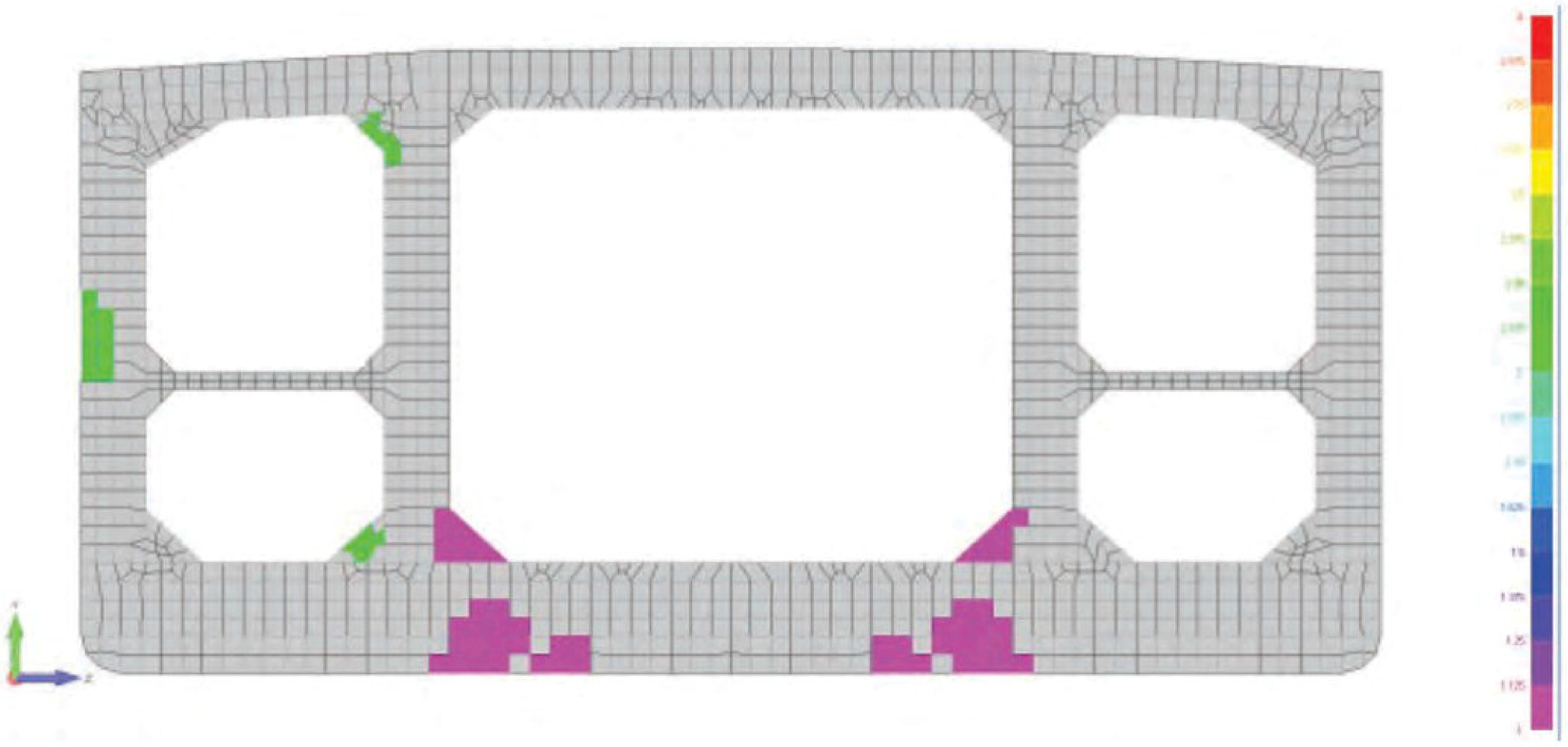
As many of these vessels are getting older and far enough into their design life or even into extension, Viking Systems is focusing on corrosion processing and is finding instances in which corrosion is developing at a faster rate than originally expected (for various reasons while in operation). In many cases, Viking is receiving special report surveys back from the unit in operation with scantlings under their substantial corrosion level or rule renewal values.

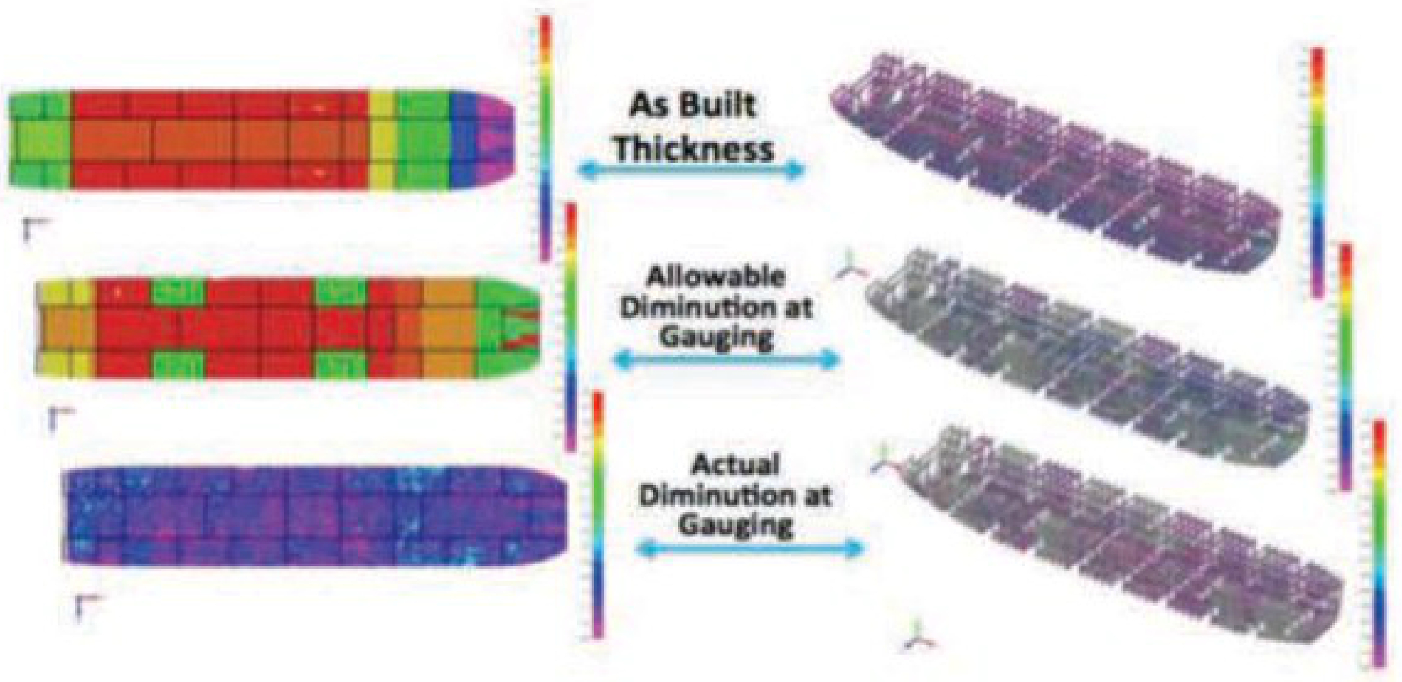
With a good representation of the current scantlings throughout the hull structure, the assessment for decision of what can be done to minimize the required steel renewal for the client begins. Starting with class software operating within the SAGA program suite, Viking identifies the minimum rule scantlings that satisfy both global strength and local scantling requirements. Viking then works through a FEA based strength and fatigue verification process ensuring that any scantling optimization done moving forward is not invalidating the structural assessment and fatigue life-predictions performed at construction.

At the point of satisfaction with a balance between minimum scantlings and structural integrity, the reassessed scantlings are then placed back through our corrosion processing program within SAGA, calculating the new scantlings at substantial corrosion while revising the steel renewal plans to reflect the new optimized scantlings.

The following examples and images come from a particular FPSO vessel in which Viking Systems has applied this methodology, drastically reducing the amount of steel renewal required in order to keep the FPSO in service.

Class uses different definitions of corrosion and allowable diminution during design and operation in the surveys after construction. For example, ABS uses a nominal design corrosion value, which varies between 1 and 2 mm for a 20-year design life for various structure types.





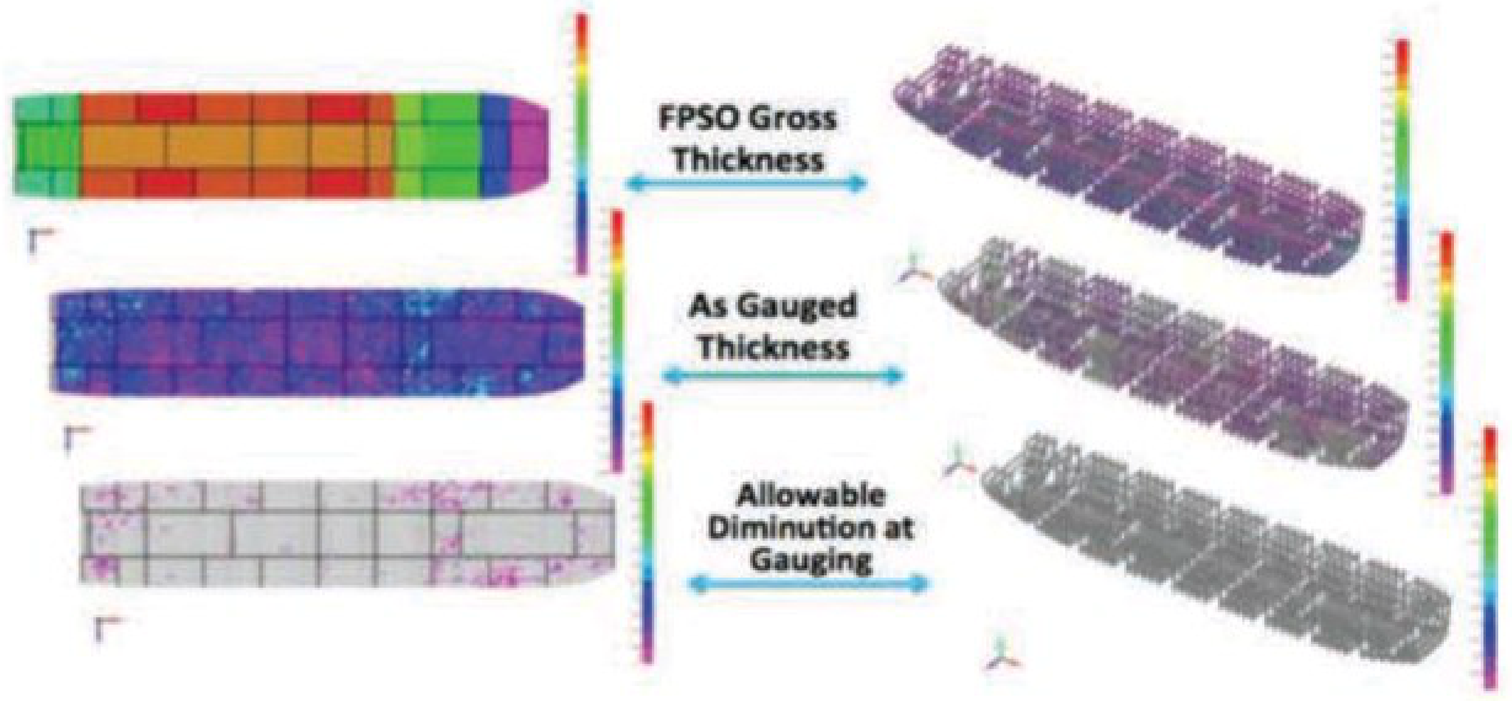


Image: Viking Systems International

After construction, the allowable diminution is defined by a percentage of the required thickness (called wastage allowance), usually between 20-25%, that can waste away before the structure has to be renewed. In a conversion situation, we start with the original tanker thickness. Using the class minimum scantling criteria with the site specific environmental conditions, Viking defines the minimum net scantlings that satisfy both the global and local scantling requirements, and then add on the Nominal Design Corrosion Value (NDCV) to define the FPSO gross thickness. Depending on the construction of the original tanker (in the instance of a conversion vessel), we often find the FPSO minimum required gross thickness to be less than the original tanker as-built scantling, which provides additional margin for future corrosion.

As we move into operations, the allowable wastage is now based upon our FPSO gross thickness, and we have two minimum thicknesses to consider. Rule renewal thickness is the first, which is as thin as the structure can go before it has to be replaced as dictated by class. The second to consider is the thickness at substantial corrosion of hull structural components, meaning 75% of the way to the renewal thickness (i.e. 75% of the wastage allowance), and is the scantling where annual special surveys are required.

Depending on location of the corrosion – main deck plating or structure in way of void spaces – we may be able to accommodate annual inspections with minimal impact on operations. With that being said, it is preferred to retain a five year special survey schedule and keep all scantling above this threshold through the end of the service life. Based on how much service life is left for the FPSO, we add a set amount of thickness to allow for additional future corrosion, and define a minimum acceptable thickness to be compared against the current gauging data. If we need additional margin to avoid plate renewal, then in some cases we can try to reduce the minimum required thickness by changing the still water allowables and/or adding additional stiffeners. However, if the scantling requirements are driven by local criteria it may not always be feasible.

Special survey reports of the hull structure typically include tabulated survey data: original and gauged thicknesses, diminution and allowable wastage based on original thickness, as well as drawings showing the location used to measure thickness. Comprehensive survey reports can include thousands of pages making it difficult and tedious to interpret the data, identify trends or draw conclusions.

For the corrosion processing within SAGA's FEA modeling capabilities, past and future corrosion is taken into consideration. Attentions are given to tanker life, service life, future corrosion allowance and all available corrosion data. These considerations are used to calculate current corrosion rates from multiple surveys, projected corrosion on non-gauged structures from similar corrosion gaugings and the location and extent of

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structure expected to corrode below the substantial thickness level before end of service life. SAGA can furthermore apply Rule Based Optimization to the FEA model to help reduce the weight of steel renewal at conversion as well as during its service life.

SAGA also allows for the calculation of average corrosion for each survey period. Due to the fact each survey takes place over certain durations of time, SAGA then calculates the median data of the gauging dates within each survey. This added tool gives the Viking Systems team of engineers the ability to investigate the adjusted corrosion level since the vessels' as-built date as well as how the average corrosion changes between each survey.

An annualized rate of corrosion between surveys is calculated in order to get a sense of whether, potentially, the corrosion rates are accelerating. In some circumstances, variations of where the gaugings were taken and how many gaugings were taken make the data unreliable as a means of calculating instantaneous corrosion. For example, if average corrosion may be more or less in a subsequent survey, this leads the data to point to a 'negative' corrosion rate, which in reality is impossible. A negative corrosion rate can also happen when, for example, a shipyard has used thicker material during construction than specified on the construction drawings.

For global model corrosion processing using the FEA model – accounting for corrosion and structural optimization – steel renewal weights can be extracted and separated by location, structural member, material grade, and renewal weight. This allows the clients and shipyards to gauge the condition of an existing vessel and the feasibility of extending the vessels' service life.

At the optimization phase of the scantling reassessment (using the example of an ABS classed vessel), information is thread through ABS ISE software, ABS HGSA Software, and lastly steel renewal tables via SAGA. FEA strength verification and FEA fatigue verification are generated through the reassessed scantling process. At this point, the renewal update is reassessed with a smaller scope of locations needing steel renewal. The below images show the extraction process (before and after) from (1) As Built Thickness, (2) Allowable Diminution at Gauging, and (3) Structure under substantial thickness:

As all FPSO and FSO owners and operators are can be faced with a high expense per metric ton (mT) of steel, scantling reassessment and optimization can be an effective tool to drastically reduce steel renewal cost as well as generating more time operating in the field. With that being said, the process requires a proven method of processing the gauging data in order to identify the location and extent of excessive wastage, as well as the experience to find the right balance between scantling reduction and hull strength and fatigue life. Structure scantlings are therefore optimized to be as minimal as possible while still meeting strength requirements. This strategy has been executed by Viking Systems on multiple vessels over the last three to five years and has proven to generate large savings of renewal steel weight required per project.