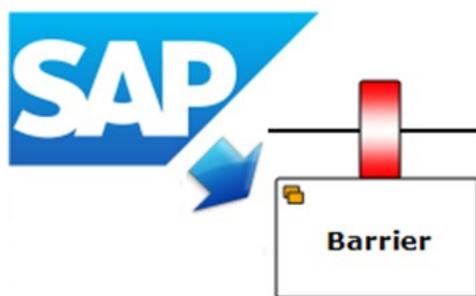




## Active Barrier Management at Al Hosn Gas - using maintenance data from SAP to ensure safe operation of the plant

Abu Dhabi Gas Development Company Ltd. (Al Hosn Gas) has extensively developed BowTies for its sour gas extraction and processing facilities in the United Arab Emirates. By integrating 'live' maintenance data of HSE Critical Equipment & Systems (HSECES) from SAP with these BowTies, the Company aims to dynamically manage the overall risk in the plant at any time during the operation of its facilities.



Al Hosn Gas has executed the Shah Gas Development, a large-scale greenfield project located 210 km southwest of the city of Abu Dhabi in the United Arab Emirates. The Shah Gas Development consists of onshore sour gas wells and production facilities, complete with gas gathering and transfer pipelines, a processing plant, product pipelines and a sulphur granulation and rail loading station.

With approximately 25% Hydrogen Sulphide ( $H_2S$ ) present in the sour gas, its handling and processing into the final products (sales gas, NGL, condensate and sulphur) poses a huge challenge in risk management.

Developing BowTies for demonstrating the control of Major Accident Hazards (MAH) is a mandatory requirement for all ADNOC Group Companies. "Al Hosn Gas has attempted to take a step beyond these requirements by developing fit-for-purpose BowTies which can actually add operational value, instead of merely being checked off as a compliance activity," explains Vishal Shah, the Technical Safety Team Leader at Al Hosn Gas. "We've achieved this by taking full advantage of the existing features within BowTieXP and are currently examining the possibility of enabling the software to communicate with other platforms, such as SAP."

### BowTies during the Project Lifecycle

Al Hosn Gas has developed and implemented a BowTie Lifecycle Process for the continuous development of its BowTies. During the lifecycle, the BowTies move from a plant-wide 'Mother' BowTie to unit-specific 'Daughter' models. At the initial FEED (Front End Engineering & Design) Stage, the organization starts with developing a 'Mother' BowTie.

As specific barriers would not have been finalized yet at this stage, the 'Mother' Bowtie essentially includes all possible preventive and mitigation barriers needed to be in place for the control of MAHs.

"This is why we call them 'Mother' BowTies," says Vishal, "as they contain all the necessary information from which BowTies in the subsequent phases of the lifecycle shall be developed. The input data for the 'Mother' BowTie is sourced from industry best practice BowTies."

With the progression of the project into the detailed engineering stage, the identified threat barriers and recovery preparedness measures are further customized. Relevant HSE Critical Systems are identified along with accountable personnel for each of these controls. Just prior to the operational stage, these BowTies are updated at unit-level, in which all HSE Critical Equipment and Systems (HSECES) are identified at tag-level, along with HSE Critical Activities and HSE Critical Integrity Activities. "We term the BowTies at this level as unit-specific 'Daughter' Bowties," explains Vishal. "From this point onwards, the BowTies are continuously reviewed and updated over the operational life span of the plant."

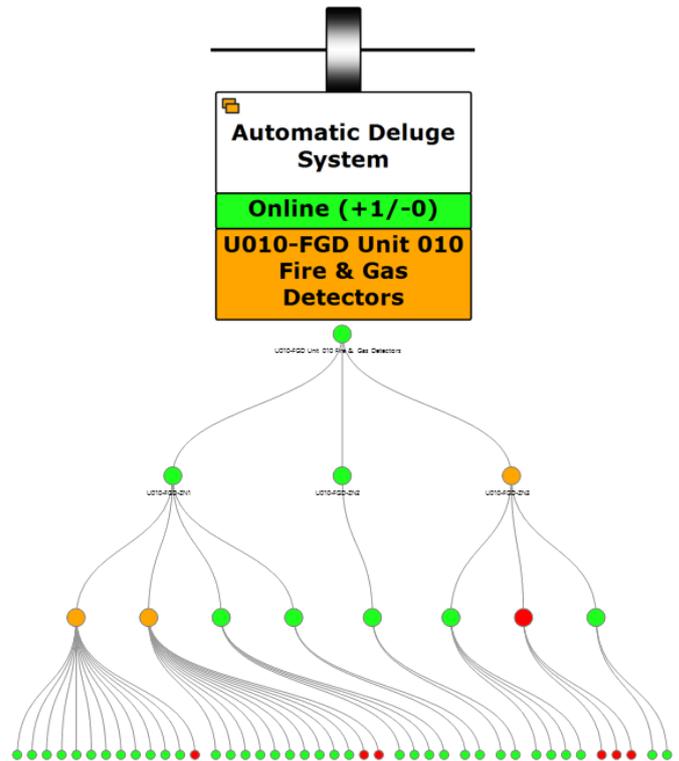
### The 2013 ADNOC HSE Award

The BowTie Lifecycle Process had been presented at the 2013 ADNOC HSE Awards, where it received recognition for its innovative technique and was commended in its approach to enhancing company performance, especially in the area of barrier based risk management.

"The implementation of the BowTie Lifecycle Process has been made possible only with the involvement of technical authorities and key personnel during various phases of the project," says Vishal. "This has led to a better understanding on their part of the measures that need to be in place to prevent threats and mitigate the severity of the consequences. Additionally, it has created a sense of ownership and accountability for the performance assurance of identified controls."

### Integrating SAP and BowTieXP

Based on the BowTies developed at unit-level, Al Hosn Gas and CGE Risk Management have jointly initiated a project for 'Advanced BowTie development and Integration with SAP'. The objective of this integration is to enhance active barrier management and enable the assessment of risk levels in the Company's facilities in real time.



Systems		
Sys. U010 Unit 010 Systems	Online (+1/-0)	No more than 0 sub systems/parts are offline
Sys. U010-FGD Unit 010 Fire & Gas Detectors	Online (+3/-0)	No more than 0 sub systems/parts are offline
Br. Automatic Deluge System	Online (+1/-0)	No more than 0 sub systems/parts are offline
Sys. U010-FGD-ZN1 Unit 010 Fire & Gas Detect...	Online (+4/-0)	No more than 0 sub systems/parts are offline
Sys. U010-FGD-ZN1-G1 Unit 010 Zone 1 To...	Online (+13/-0)	No more than 2 sub systems/parts are offline
Sys. U010-FGD-ZN1-G2 Unit 010 Zone 1 Fla...	Online (+10/-2)	No more than 2 sub systems/parts are offline
Prt. 010.23.4703A Flammable Gas Detector	Online	2016 Jan 18 16:14:45 UTC
Prt. 010.23.4703B Flammable Gas Detector	Online	2016 Jan 18 16:14:45 UTC
Prt. 010.23.4703C Flammable Gas Detector	Online	2016 Jan 18 16:14:45 UTC
Prt. 010.23.4703D Flammable Gas Detector	Online	2016 Jan 18 16:14:45 UTC
Prt. 010.23.4703E Flammable Gas Detector	Online	2016 Jan 18 16:14:45 UTC
Prt. 010.23.4703F Flammable Gas Detector	Off	2016 May 31 09:49:26 UTC
Prt. 010.23.4703G Flammable Gas Detector	Off	2016 May 31 09:49:30 UTC
Prt. 010.23.4703H Flammable Gas Detector	Online	2016 May 31 09:49:39 UTC
Prt. 010.23.4703I Flammable Gas Detector	Online	2016 Jan 18 16:14:45 UTC
Prt. 010.23.4703J Flammable Gas Detector	Online	2016 Jan 18 16:14:45 UTC
Prt. 010.23.4703K Flammable Gas Detector	Online	2016 Jan 18 16:14:45 UTC
Prt. 010.23.4703L Flammable Gas Detector	Online	2016 Jan 18 16:14:45 UTC
Sys. U010-FGD-ZN1-G3 Unit 010 Zone 1 Fire...	Online (+4/-0)	No more than 1 sub system/part is offline
Sys. U010-FGD-ZN1-G4 Unit 010 Zone 1 To...	Online (+2/-0)	No more than 1 sub system/part is offline
Sys. U010-FGD-ZN2 Unit 010 Fire & Gas Detect...	Online (+1/-0)	No more than 0 sub systems/parts are offline
Sys. U010-FGD-ZN2-G1 Unit 010 Zone 2 Fire...	Online (+1/-1)	No more than 2 sub systems/parts are offline
Prt. 010.24.2310A Fire Detector	Off	2016 May 31 09:47:56 UTC
Prt. 010.24.2310B Fire Detector	Online	2016 Jan 18 16:14:45 UTC
Sys. U010-FGD-ZN3 Unit 010 Fire & Gas Detect...	Online (+3/-0)	No more than 0 sub systems/parts are offline
Sys. GSYS Generic Systems	Off (+1/-6)	No more than 3 sub systems/parts are offline

"BowTies are only as good as the information they are based on. This depends heavily on the timing when the information was last updated, which could be a week or a year ago. At the same time, SAP contains up-to-date information on the availability of tag-item equipment / systems depending on whether they are online, or have been taken offline for maintenance / repair. However, this equipment is not mapped according to the barriers we see on the BowTie. Therefore, we could not see how the unavailability of a tag-item affected the barriers," Vishal says.

"When the two systems (BowTieXP and SAP) are integrated, it will be possible to qualify the level of risk at any time during our operation, and ensure the risk is As Low As Reasonably Practicable (ALARP)."

### Safe to proceed

Al Hosn Gas uses SAP for Preventive Maintenance. Based on the 'notifications' and 'work orders', it can be derived whether a tag-item is 'on-line' or 'off-line' at any

moment. This information could be used by BowTieXP to determine whether barriers on Major Hazard BowTies are effective – or not. This shall allow personnel from Operations, HSE and Higher Management to see at a glance if it is safe to proceed with the operations that are going on.

To cater for this, new off the shelf functionality has been added to BowTieXP. This new functionality allows users to map tag-items and safety critical systems to barriers on BowTies and set their 'hierarchy'. Also, it enables users to set the rules which determine the barrier online/offline status, based on the 'voting logic' or 'business rules' of tag-item equipment.

Vishal explains that this functionality allows Al Hosn Gas to give meaning to the on-line or off-line status of the individual tag-items. "What does it mean if a valve has been taken off-line for maintenance? Or a detector, a pump or a Blow Out Preventer? It all makes sense when you look at it from a barrier perspective."

### Overall barrier based risk model

Furthermore, a barrier in itself can be a combination of different elements.

It can be a 'pure' hardware barrier, or a combination of a piece of hardware and a procedure. A common way is to describe the difference between the barriers is 'detect', 'decide' or 'act'; it can be a combination of hardware and human intervention.

All these elements are part of the overall barrier based risk model, allowing Al Hosn Gas to have an overview to see if their risks are still "ALARP". Also, it enables the company to drill down to the individual components and the management system. If the major hazard bowties give an indication that excessive risks occur in the normal operations, due to changes in the status of barriers, Al Hosn Gas can intervene quickly.

### Active Barrier Management

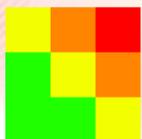
"Active barrier management has been something we have wanted to accomplish for a long time," Vishal concludes. "Once the project is finished, we will have an indication of the overall risk in the plant at any time during its operation, and ensure that it stays ALARP."

Al Hosn Gas is one of the Abu Dhabi National Oil Company (ADNOC) Group of Companies. ADNOC is a major diversified group of energy and petrochemical companies. The Group's activities include crude oil and natural gas exploration, production, refining, processing, distribution, global marketing, and the manufacture of petrochemicals. The upstream, midstream and downstream activities are conducted by 21 fully integrated subsidiaries and institutions.

ADNOC and its Group Companies strive to achieve an HSE performance that is exemplary in the Middle East and African Region. Over the past years ADNOC and its Group Companies have worked hard to promote HSE best practices and to improve its HSE performance in all aspects in its quest to achieve Operational Excellence.

Mr. Vishal Shah is a Safety & Risk Professional with a Bachelors in Chemical Engineering and holds a Masters Degree in Environmental Biotechnology. With 10 years of HSE and process safety experience in the Oil & Gas Industry, he currently leads the technical safety team in Corporate HSE at Abu Dhabi Gas Development Company Ltd. (Al Hosn Gas).

BowTieXP is a next generation risk assessment tool that uses the BowTie Method to assess risks. BowTieXP is unique in its ability to visualize complex risks in a way that is understandable, yet also allows for detailed risk based improvement plans. More than 1500 global companies have chosen BowTieXP.



# CGE

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