Barzan Onshore-Gas-Facilities Construction: Attaining Excellence Through a Comprehensive SHE&S Management System

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Summary

The Barzan Onshore Project is being developed by Barzan Gas Company Limited, a joint venture between Qatar Petroleum and ExxonMobil Barzan Limited, with RasGas Company Limited (RasGas) assigned to develop and operate the facilities upon completion. The engineering, procurement, and construction (EPC) work is being carried out by JGC as the primary contractor. JGC has subcontracted the construction execution of the work to eight major subcontractors. The project achieved 131 million man-hours without a lost-time incident from July 2012 to March 2014. The workforce peaked at more than 29,000 (or approximately 30,000) persons from multiple countries.

This paper describes the overall safety, health, environment, and security (SHE&S) management system as a three-tier model based on the EPC contract in which there are 211 SHE&S contract-related deliverables (in eight general categories) that are measured monthly by means of the SHE&S work-activities schedule. The system pertains to all parties (i.e., RasGas, JGC, subcontractors, vendors, suppliers), and this rigorous monthly accounting helps drive overall SHE&S performance. The contract combines a highly prescriptive and goal-setting approach. The project has a strong leadership team, which has exhibited daily visible commitment to SHE&S from project outset and has solidified the success of the program. Care and concern for the welfare of workers have been top priorities for the leadership team. The systematic approach combined with the leadership team's efforts has delivered a great foundation on which to build and sustain SHE&S performance at site.

Introduction

The Barzan Onshore Project is being developed by Barzan Gas Company Limited, a joint venture between Qatar Petroleum and ExxonMobil Barzan Limited, with RasGas assigned to develop and operate the facilities. The objective for the Barzan Onshore Project is the economic development of a high-quality, reliable, and fully integrated sales-gas facility that further monetizes Qatar's North field resources (**Fig. 1**) to supply gas to the domestic market for power generation and water desalination.

The facilities are located on a greenfield site within Ras Laffan Industrial City (RLC). The facilities will receive wellstream fluids from two offshore pipelines and process the fluids to the final products of sales gas, ethane, propane, butane, condensate, and molten sulfur by means of two gas-processing trains that are integrated with utilities and other onshore process facilities (**Fig. 2**). The project will receive electric power, desalinated water, and seawater from the common RLC facilities. The site occupies 3.6 km^2 (890 acres).

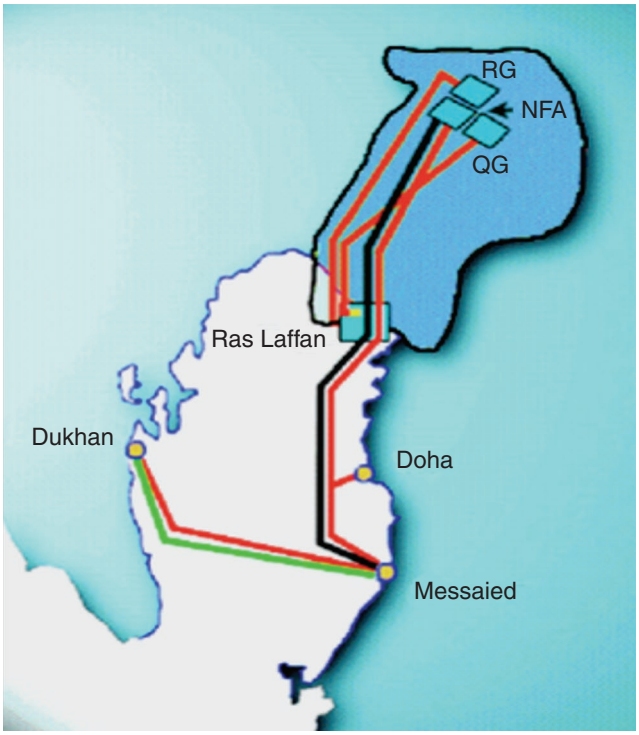

Fig. 1—Qatar gas fields.

JGC was awarded the engineering, procurement, and construction (EPC) contract on 1 January 2011. The project workforce includes workers from 45 different nationalities using more than 20 languages. JGC has had eight principal subcontractors engaged in the project. The majority of the subcontractors have had a multidiscipline scope (e.g., civil, structural steel, piping, electrical, instrumentation), with the exception of the heavy-lift subcontractor and the tank-specialist subcontractor. The manpower peaked at 29,000 from November 2013 through June 2014.

To date, the project has displayed world-class safety, health, environment, and security (SHE&S) performance in large part because of a comprehensive SHE&S management system and senior-management commitment to an Incident and Injury-Free® (JMJ Associates 2014) workplace, emphasizing safe-work planning and "building strong relationships" between supervisors and workers. These actions in turn create a workplace-safety culture in which personnel want to follow the safety requirements rather

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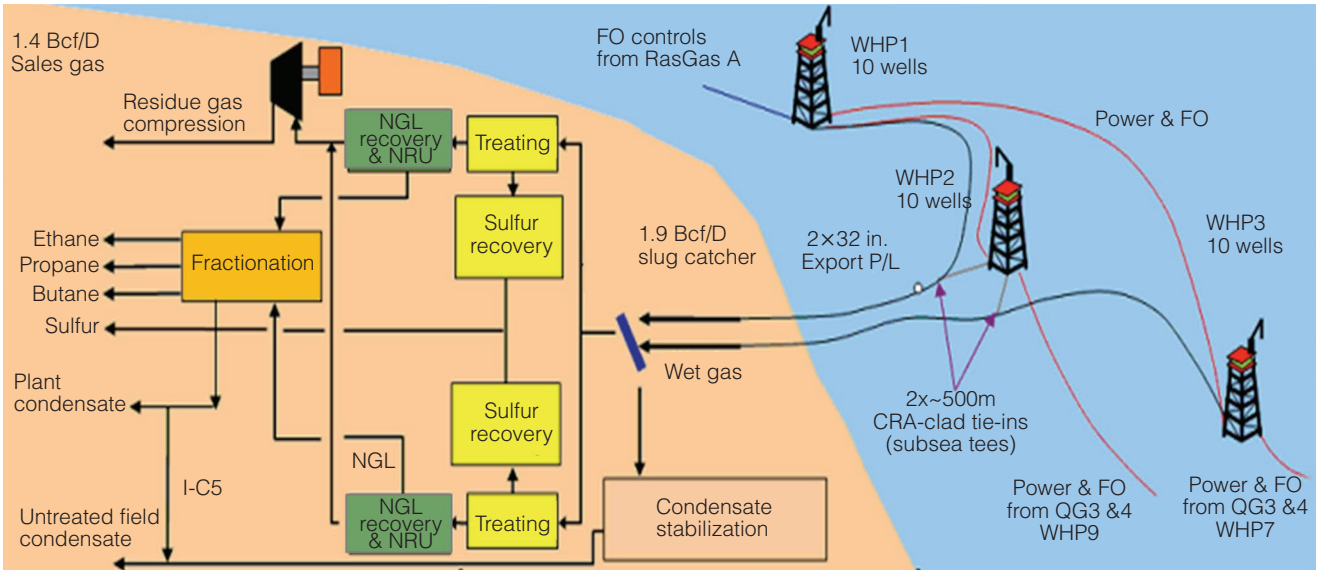

Fig. 2—Barzan Gas Plant: simplified process overview. (Note that in the figure, NGL is natural-gas liquids, NRU is nitrogen rejection unit, P/L is pipeline, FO is fiber optic, and CRA is corrosion-resistant alloy.)

than feel merely obligated to do so. This world-class performance is demonstrated in part by the project's lagging metrics of a total recordable incident rate (TRIR)[1] of 0.172 and lost-time incident rate (LTIR) of 0.005 on the basis of 160 million man-hours. Recognition of this achievement occurred on 26 April 2013 and again on 6 May 2014, when JGC received the 2012–13 Gold Award from the Qatari Minister of Energy and Industry as the best contractor for SHE&S excellence in the Qatar Oil and Gas Industry.

A comparison has been drawn between the project's performance indicators and the International Oil and Gas Producers (OGP) 2012 annual report (OGP 2013) (global and Middle East regions), including fatal-accident rate, TRIR, and LTIR (**Table 1**).

This paper presents some of the key elements of the SHE&S management system:

- Management commitment and leadership
- Worker/supervisor involvement and safe-work planning
- SHE&S work activities schedules
- Incident and case management
- Behavior observation and intervention
- Selection and management of subcontractors
- Worker recognition
- Camp management and worker welfare
- Metrics for continuous, sustainable improvement

It further illustrates the way in which strong SHE&S requirements in an EPC contract can deliver very positive results for effective project management. This paper provides a macro-overview of the SHE&S management system, highlights six "stellar areas" as well as six "challenges," and demonstrates the correlation of leading and lagging indicators to the overall SHE&S performance project-to-date. Note that certain elements of the SHE&S management system (e.g., security management; premechanical completion and simultaneous operations; and project plant-design issues for safety, health, loss prevention, and ergonomics) are not discussed in this paper.

Project SHE&S Management System

The project safety, health, environment, and security (SHE&S) management system is a three-tier model based on the engineering, procurement, and construction contract in which there are 211 SHE&S contract-related deliverables (in eight general categories) measured monthly by means of the SHE&S work-activities

Indicator*	Barzan	OGP Global	OGP Middle East
Fatal-accident rate	0	0.005	0.004
LTIR	0.005	0.096	0.050
TRIR	0.172	0.348	0.204

*OGP data have been normalized from 1 million man-hours to 200,000 man-hours (Occupational Safety and Health Administration reporting criteria).

Table 1—Comparison between the project's performance indicators and the OGP 2012 annual report (OGP 2013).

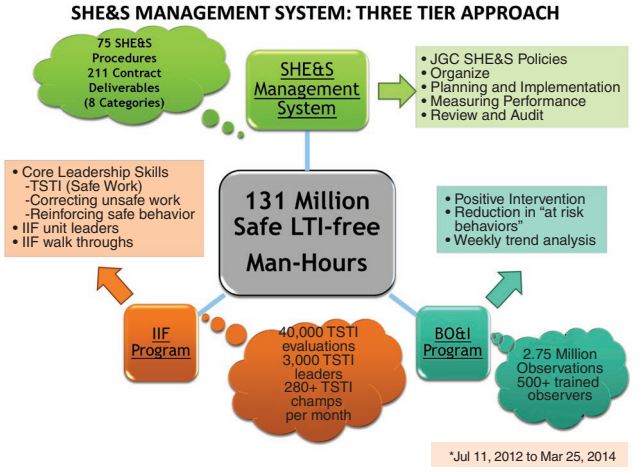

Fig. 3—SHE&S management system: three-tier approach. (Note that in the figure, TSTI is total safety TI.)

schedule (**Fig. 3**). The system pertains to all parties (the RasGas project-management team, hereafter referred to as Company; JGC, hereafter referred to as Contractor; and the subcontractors, vendors,

[1]Recordable incidents include fatalities, lost-time incidents (LTIs), medical-treatment incidents, restricted-work-day incidents, and TRIR=(recordable incidents)×200,000/total man-hours and LTIR=(LTIs)×200,000/ total man-hours. This is applied as per Occupational Safety and Health Administration report and record-keeping criteria.

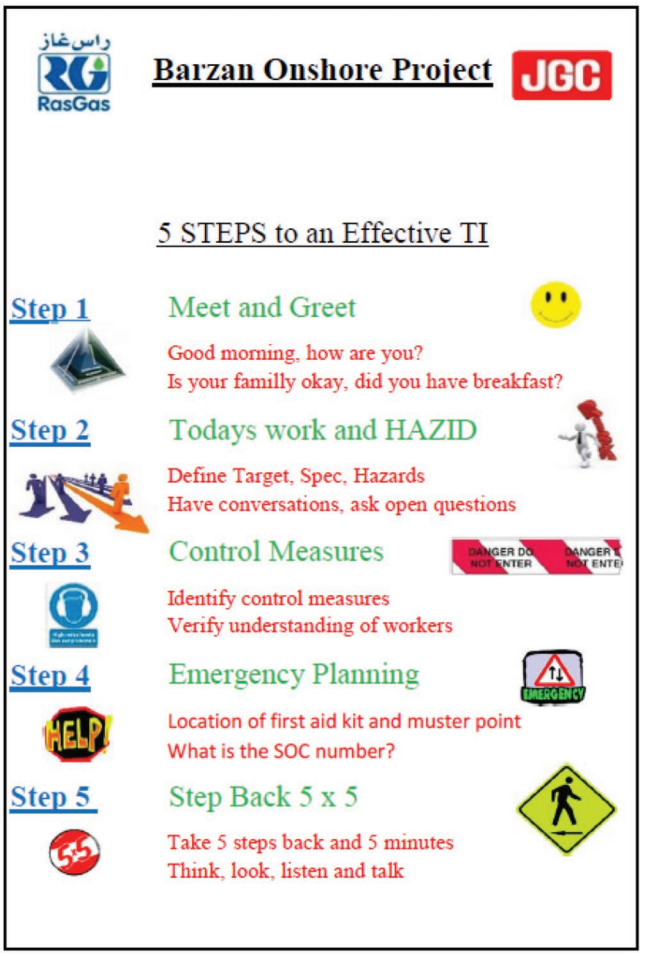

Fig. 4—TI prompt card (five steps to an effective TI). (HAZID= hazard identification).

suppliers, and site visitors), and this rigorous monthly accounting helps drive SHE&S performance. The contract requirements combine a highly prescriptive and goal-setting approach that has, to date, delivered a great foundation on which to build and sustain SHE&S performance at site.

The system follows the classical "Plan, Do, Check, Act" model. A closer look reveals that the system contains a first tier of standard construction-project SHE&S policies and procedures, which adhere to conventional "organizing, planning, implementing, measuring, reviewing, and auditing." The second tier focuses on behavioral observation and intervention (BO&I) at the work site, and the third tier is based on an interactive Incident and Injury Free (IIF) (JMJ Associates 2014) workforce for building strong, sustaiable "relationship" activities between workers and supervisors.

The risk-management process defines the project's safe-work planning and execution and makes up an integral part of the overall SHE&S management program. The main tools used for risk assessments include the project's quantified-risk assessment, which has been performed at the "front end" of the project design, followed by execution-assessment tools including risk register, construction-risk assessment, and health-risk assessment. All site activities are carried out on a permit-to-work (PTW) system requiring, as a minimum, an approved method statement and job-safety analysis (JSA), with a task instruction (TI) just before starting the work (see example of a TI prompt card in **Fig. 4**). A separate TI is used for premechanical-completion (PMC) activities. The risk-management process thus consists of six main tools: the quantified-risk assessment, risk register, construction-risk assessment, health-risk assessment, and the final practical JSAs and TIs.

Daily safe-work planning, considered the most important element of the SHE&S management system, is implemented through mandatory TIs given to the workforce at the beginning of the work shift, after lunch, and as the work front changes. As part of the safe-work planning process, the TI addresses the requirements of the PTW and the specific JSA and the method-statement requirements for the particular work activity. Because the TI is an integrated approach focusing on the continuous delivery of top "safety, quality, and progress," the TI creates pockets of coordinated effort at site, with endless positive possibilities if delivered effectively by the supervisor and implemented by the workforce.

TI "skills-improvement campaigns" have been continuous since the start of site construction. Initially, more than 250 TI coaches were trained to assist frontline supervisors to improve their TI skills in real time in the field and help identify TI champions through an ongoing evaluation process. TI champions are given special vests to identify them as such on the work site.

In August and September 2013, all of the project's frontline supervisors attended TI breakfast sessions, during which some 3,000 charge hands and foremen (24 sessions of approximately 125 supervisors per session) were retrained in TI and Step Back 5×5 to help reinforce safe-work planning, hazard recognition and control, and the need for positive, ongoing worker/supervisor communications at the work sites. The Step Back 5×5 process is a personal-risk assessment that ensures engagement of the mind, task, and surrounding area before starting the work (i.e., "think, look, listen, talk" about the work, the hazards, and how to control the hazards).

The breakfast sessions hosted an interactive dialogue between a session facilitator and the supervisors in their respective languages, with senior-management commitments given by the Company, Contractor, and the subcontractors. A 7-minute in-house video was shown on how to conduct a good TI and Step Back 5×5 for overall improvements for a safety "first," quality "must," and construction "best" integrated approach. Finally, a championship competition was established in which the top three TI deliveries by a charge hand from each subcontractor (areawise) would be awarded every 3 months until project completion.

TI and Step Back 5×5 are further enhanced by daily observations from trained personnel from the Company, Contractor, and subcontractors who observe good and bad practices at the work site, intervene, and record their observations. The program was revamped in late 2012 to strive for better participation by all organizations, and produce more-meaningful BO&I results to help change worker behavior and perceptions about safety, thereby helping to drive real improvement in the work site. Today, there are more than 1,200 observers actively participating in this program, recording more than 150,000 observations per month. Similar to the TI breakfast sessions, the BO&I coordinators have also held a breakfast session for refresher training as part of continuous improvement for the program.

More than 5 million observations have been generated project-to-date, representing BO&I, plant, maintenance, vehicle, and transport observations. The BO&I program provides detailed training and an enhancement of supervision skills for the reinforcement of worker safe behavior and positive intervention of unsafe behavior. Monthly and quarterly reports provide information for specific behavioral trends for subcontractors by area, craft, activity, behavior, or time interval.

To supplement daily safe work planning with the TI and Step-Back 5×5 tools, and the ongoing BO&I reporting, subcontractors are conducting "tool box talks" on a daily basis to help reinforce lessons learned, safety alerts, bulletins, posters, and campaigns. In SHE&S induction training, all personnel are trained in the use of a "stop work" card, with which a worker enforces the Contractor policy that allows anyone to stop unsafe work and/or an unsafe

Field Survey			Focused Inspection			Audit		
1	Flagman and Operations	30-Jul-12	28	Excavation	22-26 Jan 12	59	Heat Stress Prevention Plan 2012	20-Apr-12
2	Banksman	9-Aug-12	29	Electrical Safety and Lock-Out Tag-Out	9-22 Feb 12	60	Site Energency Preparedness and	8-May-12
3	Double Orange /Red Flag	4-9 Aug 12	30	Lifting and Rigging	11,14,17 & 19 Apr 12	61	Fitness for Duty	5-Jul-12
4	Crane Operator	12-23 Aug 12	31	Permit to Work	6-8 Mar 12	62	Waste Management	6-Sep-12
5	PPE	18 Aug - 2 Sep 12	32	Heat Stress Prevention	6-20 May 12	63	Incident Reporting	20-Oct-12
6	Transport and Pedestrian Safety	27-28 Aug 12	33	Scaffolding	2-23 Jul 12	64	SHE&S Training	8-Nov-12
7	Fire Extinguisher and Fire Watch	08-26 Sep 12	34	Working at Height	25 Aug - 06 Sep 12	65	Audit and Inspection	30 Jan - Feb 7 13
8	Hand Tools Survey	10-15 Nov 12	35	Fueling Operations	03-10 Sep 12	66	Camp (Heat Stress Prevention)	4-Feb-13
9	Wedge Size Survey	2-8 Dec 12	36	Barricades	28-Oct-12	67	Plant and Equipment Maintenance	9-Feb-13
10	TBT Survey	5-12 Dec 12	37	Hand and Potable Power Tools	9-Feb-13	68	Camp (Equipment and Inspection Maintenance)	10-Feb-13
11	Power Tools	3-4 Feb 13	38	Environmental Monitoring	9-Feb-13	69	BO & I Program	28 Feb - 06 Mar 13
12	Hard Hat Survey	5-6 Feb 13	39	PPE compliance	14-Feb-13	70	Competent Person Register	21-29 Mar 13
13	Double Eye Protection Survey	12-14 Feb 13	40	PTW	30-Mar-13	71	Camp Emergency Preparedness	10-Apr-13
14	Excavation Safety Survey	5-May-13	41	LMRA	14-Mar-13	72	Respiratory Protection	10-17 Apr 13
15	Machinery Safeguard	5-Jun-13	42	Hazardous Waste	3-Apr-13	73	Fire Prevention and Protection Plan	25 Apr - 03 May 13
16	Power Tool Training	8-27 June 13	43	Camp Emergency Preparedness	3-Apr-13	74	Health Audit	15-17 Jun 13
17	Milestone Gift	17 June - 21 Jul 13	44	Heat Stress Prevention	4-Jun-13	75	TCA/CTCA Control Programme	02-09 Jul 13
18	Heat Stress Monitors Survey	1-2 Jul 13	45	Confined Space	13-Jun-13	76	HSP Compliance Knowledge	16-25 Jul 13
19	Heat Stress Program Compliance Inspection	18-20 Jul 13	46	Knowledge and Enforcement of Heat	25-Jul-13	77	Camp Kitchen Worker and Sanitation	3-Aug-13
20	Work Rest Cycle (Heat Stress Prevention)	23-25 Jul 13	47	Temporary Construction Aids	28-Sep-13	78	Craft Training Program	18-25 Aug 13
21	Supervisor Knowledge Assessment -Heat Stress	5-7 Aug 13	48	Electrical Safety and Lock-Out Tag-Out	30-Oct-13	79	Sustainability of Incident Reporting	11-19 Sep 13
22	Confined Space Entry	11-24 Aug 13	49	Grating,Plate and Rail Removal	30-Oct-13	80	Chemical Management and Waste Management	05-09 Oct 13
23	Approved PPE Survey	24-Aug-13	50	Camp:Spill Prevention & Waste Management	30-Oct-13	81	Fall Protection and Dropped Object	12-19 Nov 13
24	Heat Stress Program Survey (Construction)	21-28 Sep 13	51	PMC Activities (PTW,TCA & General Conditions)	30-Nov-13	82	Wet Weather Mitigation	07-14 Dec 13
25	Power Tools Guarding	21-Nov-13	52	TSTI & Step Back 5x5 Quality	30-Dec-13	83	PMC/SIMOPS Permit to Work	23-Jan-14
26	Gin Wheel Survey	12-13 Dec 13	53	Camp: Building Condiion and Maintenance	30-Dec-13	84	SHE&S Management System Assessment	02 &10 Jan 14
27	Wet Weather Preparation	24-26 Dec 13	54	Occupational Health Practices	28-Feb-14	85	Scaffolding	19 - 27 Feb 14
			55	Confined Space	30-Mar-14	86	PMC/SIMOPS Management	16 -26 Mar 14
			56	Last Minute Risk Assessment (NSH)	30-Apr-14	87	Respiratory Protection Program	13-24 Apr 14
			57	PMC/SIMOPS Permit to Work	15-Apr-14	88	Heat Stress Prevention (Preparation and Implementation)	25-31 May 2014
			58	Hearing Conservation	15-May-14	89	Plant Vehicle Equipment Maintenance	22-Jun-14

Fig. 5—SHE&S audits, focused inspections, and field surveys summary (2012 to 2014). (Note that in the figure, PPE is personal protective equipment, LMRA is last-minute risk assessment, and SIMOPS is simultaneous operations.)

Area	No. of Continuous Days w/o Incident & Injury	Cumulative No. of Incident & Injury Free Days			
		Week 177	MTD	YTD	PTD
Train 1 (A100)	10	7	23	135	926
Train 2 (A200)	18	7	23	133	878
Common Process (B100)	16	7	26	143	933
Common Process (B200)	9	7	25	145	921
Utilities (C100)	31	7	25	142	925
Off-site Utilities	70	7	26	144	899
Nonprocess Building (C300)	34	7	25	144	670
Offplot	733	7	26	147	733
Temporary Site Facilities (TSF)	1	6	22	136	906
PMC Controlled Area	12	7	26	142	293

Fig. 6—IIF® days (per area).

practice. All of these actions help drive work-site-hazard awareness and positive intervention to "stop unsafe work."

Formal SHE&S audits are performed monthly to verify compliance to project SHE&S policies and procedures. Thirty audits have been completed to date. Audits are led by the Contractor, with participation from the Company and subcontractors. Auditing involves documentation reviews and field verification. Reports are prepared with action items assigned. The action-tracking register (ATR) is used to track and close out audit report corrective actions; the ATR is reviewed by the Company and the Contractor bimonthly to ensure that items are being closed out in a timely manner.

Similar to the SHE&S audit program, the project has developed a SHE&S-focused inspection and field survey by which specific topics are targeted on the basis of incident-report trends and workplace hazards and concerns, and to verify compliance. The Company and the Contractor SHE&S personnel conduct the inspection of their respective areas with a specific checklist, and teams generally have 4 to 5 weeks to complete up to 10 inspections per team. Teams are expected to arrange for corrective action during the inspection. Statistics are collated and analyzed to identify root causes identifying follow-up actions, which are tracked in the ATR. Thirty-one focused inspections and 27 field surveys have been completed to date. **Fig. 5** is a listing of the audits, focused inspections, and field surveys that have been completed to date. The frequency of these have been dictated by changing work fronts, relevant issues, and the risk-management process to ensure that work activities are planned and executed safely. For example, heat-stress (HS) audits and focused inspections are conducted during the HS period, especially the initial stages, to ensure compliance to program requirements.

During 2013, the construction PTW program was expanded to include a separate PTW system for PMC and SIMOPS activities that occur during completions and commissioning activities. The PMC PTW process is set up such that, when hydrocarbons are introduced into the plant in 2014, there will have been a gradual transition to the more rigorous RasGas PTW system, which will become the requirement for the operating plant.

Eleven team-building workshops have been held project-to-date with Company, Contractor, and subcontractor staff. The goals include developing and implementing sustainable solutions to work-site challenges, and promoting a caring, safe environment for all workers, both in the camps and on-site. Additionally, six commitment team-building workshops were held with key site personnel in 2012 and 2013. Six work-site-climate surveys have also been conducted, with the most recent (May 2014) resulting in the TI breakfast sessions for TI improvement.

For this paper, six stellar areas and six improvement areas are described on the basis of lessons learned project-to-date. Although all elements of the program contribute significantly to the obtained results, the 12 stellar areas and improvements have been of particular interest because of varying challenges for the project (e.g., promoting worker welfare as a primary concern) at the work site and in the camps.

Leading and Lagging Indicators

Innovative safety, health, environment, and security (SHE&S) work-activity schedules by the Contractor and subcontractors have exceeded expectations in most areas, and greatly drive the site and camps' overall SHE&S performance. The activity schedules include the items that are tracked and followed on a daily, weekly, and monthly basis. Some 20 performance indicators are reported to senior management at the monthly SHE&S meetings and are reviewed with the sponsors at the quarterly meeting.

The following are some key leading indicators that are monitored and reported regularly:

- Incident- and injury-free (IIF) days (area-/subcontractorwise, **Fig. 6**)
- SHE&S training hours
- Close out of audit and incident investigation actions per established schedule
- Compliance monitoring (permit-to-work, task instructions, waste management)
- Kilometers driven by project vehicles
- In-vehicle monitoring system: red, amber, green reports

The following are some of the key lagging indicators that are also monitored and reported regularly:

- Lost-time-incident- (LTI-) free man-hours
- Total recordable incident rate (TRIR)
- First-aid case frequency rates

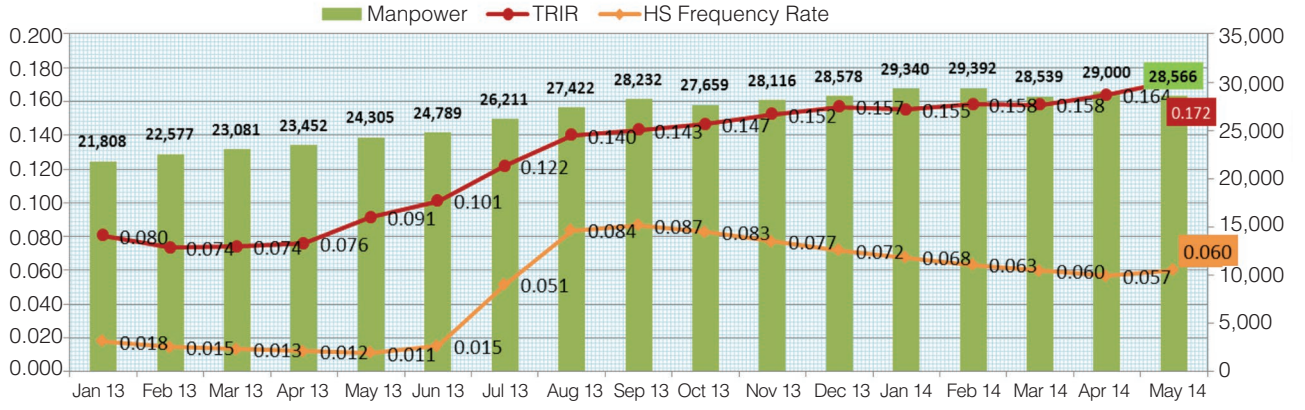

Fig. 7—Manpower and incident rates.

Fig. 8—Camp celebration events.

- Injury frequency rates
- Heat-stress (HS) incident frequency rates: Heat-illness prevention is a major initiative during HS months. The program includes activities such as continuous monitoring of the heat index, a visible flag system across the site to signify ranges of heat index, short-message service text notifications, annual refresher training, air-conditioned "cool-down shelters," a "no water, no work" policy, reacclimatization, supplemental food, and a work/rest cycle.

The lagging indicators are also analyzed and correlated on a monthly basis to identify further possible areas of improvement and reasons behind changing trends. As noted from the graphs (**Fig. 7**), there is a direct correlation between the increased TRIR and the HS-incident rates during the 2013 HS season.

The major focus is placed on the leading indicators, as a proactive measure, to drive and sustain the SHE&S performance on the project. As such, IIF days are monitored and communicated areawise. Thus, the SHE&S program is geared to full achievement of an IIF site, while maintaining high quality standards and good progress. Fig. 6 is an example of IIF days, which are broken down into the major areas at site. The subcontractors break down these figures to evaluate which exact areas, disciplines, and group leaders are achieving the objective of the IIF site.

For lagging indicators, the TRIR is especially important because it monitors the frequency of the more-serious incidents onsite. An increased number of medical-treatment cases that occurred in July, August, and September of 2013 were in part a result of the heat-illness cases experienced during the summer season. Dedicated meetings were conducted to address heat-illness cases during that period in addition to a review by project management from the Company, Contractor, and subcontractors on a weekly basis. The heat-illness-prevention program has also been adjusted during this period, with added measures taken to improve the implementation and effectiveness of the program.[2] Fig. 7 indicates the TRIR and HS frequency rate.[3] In the summer months, HS cases make a significant contribution to the overall TRIR, and the project-management team meets weekly to evaluate data and determine the overall program performance.

Six Stellar Areas

Camp Management and Worker Welfare. Significant efforts are expended in the camps to sustain and improve worker welfare (such as accommodation, menus, recreation, and internet cafes). A monthly camp-management meeting is held with project management from the Company, Contractor, and subcontractors to review camp programs and issues. These meetings are supplemented by monthly subcommittee meetings for food and nutrition, welfare and recreation, and residence lodging. Actions have included significant renovations to kitchens, ablution facilities, and living quarters. Issues addressed at the meetings include food quality; accommodation; recreational and leisure activities; communication with family; and safety, health, hygiene, and security issues. Ongoing field inspections and surveys ensure that an environment of continuous improvement is fostered for camp operations. This oversight program has led to improvements for safe bus loading and unloading at the camps, as well as recreational enhancements and health and hygiene improvements in the canteens, kitchens, accommodations, and ablution facilities.

Examples of camp activities include olympic-style competitions; cultural concerts; and safety, health, environment, and security (SHE&S) celebrations (**Fig. 8**). A camp operations and maintenance team-building workshop was held in December 2012, with recommended actions implemented in 2013. There have been six major celebration events in the camps, recognizing 10, 25, 50, 80, 100, and 130 million lost-time-incident-free man-hours. Professional musicians, dance troupes, comedians, actors, and actresses have been brought in from India, Japan, and Pakistan to celebrate these achievements. The concerts also included interactive booths with games and prizes, creating a carnival-like atmosphere that proved to be very popular with the workforce. The concerts blend different cultures together, which is highly appreciated and much-anticipated by the workforce. A 2-hour digital video has been compiled to capture all these events, which have been distributed to all workers to share their project memories with their families when they return to their home countries.

In case disciplinary actions are required, a camp compliance tribunal is held for violation(s) of camp rules. Per Ras Laffan Industrial City (RLC) security, the Barzan Project camps have had the lowest rate of security incidents based on the past records of other camps in the entire history of RLC. This great achievement bears testimony to the systems that are in place to manage the camps.

Environment. The Barzan Onshore Project is being built in compliance with the Qatar Ministry of Environment consent-to-construct permit, which includes construction and commissioning of the Barzan Onshore Plant and associated offshore facilities. Periodic reports are submitted in support of the consent-to-construct permit and the project environmental action plan. The offshore and plant facilities will be started up through the issuance of the Ministry of Environment consent-to-operate permit.

Waste management on the project is well-controlled, and a centralized approach is followed to ensure accurate tracking of waste and alignment with the project waste-management principles of recycle, reuse, and reduce. All waste passes through the interim waste-management facility, where it is segregated and the relevant principle applied. The recycling rate on the project is 80% of waste generated, which is primarily because of this centralized approach. A full-time carpentry team is also assigned in the interim waste-management facility and a portion of their duties includes repurposing and/or recycling wood to make useful items such as rest shelters, fencing panels, bookshelves, and rest benches.

[2]First-aid case (FAC) rate=(FAC)×200,000/total man-hours and injury rate=(FAC+recordable incidents)×200,000/ total man-hours.

[3]HS frequency rate=(heat-related FACs+heat-related recordable incidents)×200,000/total man-hours.

Fig. 9—Management and personnel participate in RLC beach cleanup.

Fig. 10—SOC and emergency exercises.

Fig. 11—PRT.

Chemical and hazardous materials are strictly controlled on the Barzan Onshore Project, and storage facilities have been adequately designed and constructed. The designs were reviewed and approved by the RLC fire department to ensure that life-safety requirements were met. The facilities are inspected on a regular basis and chemical and hazardous-material permits are issued. The requirements that are monitored include ventilation, air temperature, spill containment, spill response, fire-detection and -protection facilities, and eye-wash facilities.

The project has held four beach cleanup drives in RLC to contribute to environmental awareness and protection. The beach cleanups were highly successful and included participation from management as well as project personnel (**Fig. 9**).

Emergency Management. A robust emergency program is in place that includes a centralized communications center; security operations center (SOC); trained project on-scene commanders; a 24-hr/D, 7-D/week (24/7) project rescue team (PRT) that is professionally skilled in "rescue at height" and "rescue in confined spaces;" and regular emergency exercises and drills, including joint drills with RLC emergency-management services, as shown in **Figs. 10 and 11.**

The SOC—a communications hub that collects and distributes information to relevant personnel—is manned 24/7 and manages initial incident reporting and cascading of messages. As such, the SOC is a "nerve center" for incident reporting at site and in the camps, resulting in a more seamless response and management of incidents. Eight joint major drills have been conducted with RLC emergency-management services. There are two field first-aid stations (also staffed 24/7) to assist the site medical-aid center and provide faster response in the field. In the camps, the clinics are staffed 24/7. The system works very efficiently, and multiple incidents can be handled smoothly at the same time, with multiple responses in different areas at site.

Planning and exercises have also been carried out for major emergencies. As such, project management has been trained in major emergency response and drills have been carried out in this regard. An incident coordination center has been set up, from which project management mobilizes in case of major emergencies. The room is equipped with communication devices to gather information from the SOC and the field. The room also has been set up with facilities that can feed live pictures from the site in an actual emergency.

The PRT comprises an 11-man team and a project-rescue lead. They work proactively with the construction personnel to eliminate and mitigate (as much as possible) fall and confined-space risks. Since April 2013, there have been 16 rescues from height (two at the 40-m level) and 321 calls for medical assistance at the work

Fig. 12—CIT during incident investigation.

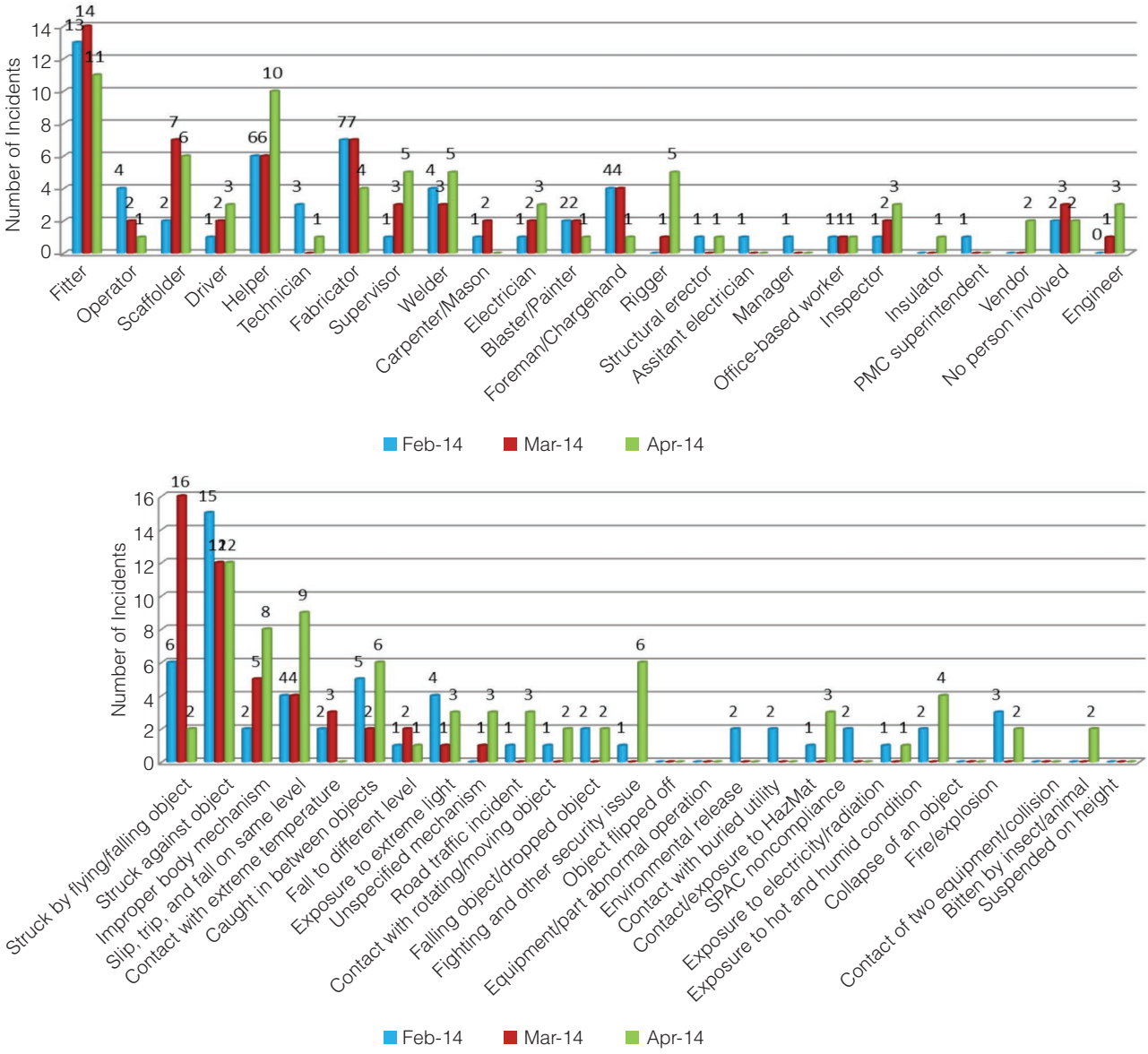

Fig. 13—Examples of key charts from monthly incident analysis. (Note that in the figure, HazMat is hazardous materials and SPAC is standards, policies, and administrative controls.)

site. As part of rescue planning, the PRT has a "confined-space protocol" established through the central permit-to-work office. The PRT performs site visits to monitor confined-space activity throughout the project to become familiar with the activity, but also to verify rescue plans are in place. At peak construction, more than 300 such visits were performed in a month. The team also conducts surveys for access at height and updates key plans indicating the location of permanent and temporary access to elevated areas.

Incident and Case Management. Effective incident and case management is a cornerstone in our emergency preparedness program, with the mandate to always take care of the injured person

Fig. 14—Pedestrian and vehicle safety brochure.

first and the incident investigation second. Prompt responses are vital to handling illnesses and injuries in the camps or at site. Illnesses and injuries are managed by health professionals who follow a case from identification through conclusion, including visits to the site medical-aid center, RLC clinics, or local hospitals. Case managers, also called patient escorts, provide information to the core investigation team (CIT) to support the incident-investigation process. The patient escorts provide information only, and the classification of injuries is managed through an entity separate from the project (registered occupational-health center). Injuries are reported as a mandatory requirement to the relevant Qatari authorities (starting with RLC). Audits and inspections are carried out by independent regulatory bodies to ensure tranparency and accuracy of reporting, as well as classifications.

The CIT consists of some 213 SHE&S professionals from the Company, Contractor, and subcontractors who are trained in incident-investigation techniques (**Fig. 12**). The process includes TapRooT® (by Systems Improvement, Inc.) analysis for all recordable incidents and high-potential (HiPo) near misses. Upon completion of the investigaion, the corrective actions are captured in a master action-tracking register (ATR), with actions closed out only when suitable evidence is submitted for closure. Recordable incidents and HiPo incidents are presented to the management incident-review committee on a weekly basis to review all significant incidents and actions and to ensure that lessons learned are shared within the project.

The process has proved to be highly effective, and the investigation team involves line management from the different subcontractors as well as subject-matter experts in certain instances. The expertise of such personnel is especially valuable in more-technical investigations and creates a sense of ownership and responsibility with the relevant management. The incidents are analyzed on a monthly basis to identify trends and areas of concern that, in turn, are presented in the monthly SHE&S steering-committee meeting (**Fig. 13**).

Subcontractor SHE&S Management. The Contractor and its subcontractors are required to meet the following minimum site supervisory ratios:

- SHE&S supervisor to worker 1:200
- Field SHE&S adviser to worker 1:50
- Discipline supervisor to worker 1:20
- Foreman/charge hand to worker 1:10

For late shift or nightshift work, the Contractor and its subcontractors increase all four areas of supervision by a factor of 15%. Per the engineering, procurement, and construction contract, all SHE&S officers and supervisors are critical SHE&S positions and must be approved by the Contractor and Company. In addition to these positions meeting professional-experience requirements, the standard qualification requires the incumbents in these positions to hold a current NEBOSH (National Examination Board in Occupational Safety and Health) certificate in Occupational Safety and Health, or attain the qualification within 6 months of mobilization to the site. More than 200 personnel have been trained in NEBOSH at the site.

The Contractor uses the key-performance metrics agreed between the Contractor and Company (as listed previously) to evaluate the SHE&S performance of each subcontractor. The subcontractors' SHE&S management systems have been modified to adhere to the Contractor SHE&S management system, and before site mobilization, each subcontractor had to pass an SHE&S readiness review conducted by the Contractor and the Company. This in-depth review consists of a holistic review of the subcontractor's SHE&S program, and is currently being undertaken for the premechanical completion subcontractors that are sub-contracted by the Contractor.

A key component of the SHE&S management system shared between the Contractor and its subcontractors is the sharing of lessons learned. To date, the Contractor and its subcontractors have issued more than 1,000 SHE&S-related communications, including SHE&S alerts (for incidents), bulletins (information and awareness), posters (promotions), and good and bad practice (for in-field coaching during TIs). These are then shared sitewide and posted on bulletin boards.

Fifty-seven SHE&S training courses are in place, complemented by seven craft-skills training courses. Craft-skills training is owned by the construction staff, with SHE&S oversight. An eight-module (2 to 3 hours/module) supervisor's skills-training program helps increase supervisor SHE&S knowledge, with particular emphasis on TI, Step Back 5×5, observation reporting, and incident reporting. Training is provided for 41 nationalities in five languages, and is performed through the Contractor's and subcontractors' qualified trainers, who must also meet a qualification standard analogous to NEBOSH.

New workers and inexperienced workers have a unique identification. New workers have hard hats with new worker or acclimatization stickers that must be worn for either 2 or 4 months, depending on their work experience. Analysis has shown that approximately 70% of injuries to date on the project have occurred for persons under the age of 25. Younger workers are identified with orange tape on their hard hats to ensure that they are paired with experienced workers.

Relationship building, worker recognition, reinforcement of safe behaviors, positive worker interactions, and interventions are promoted through walk-throughs. Weekly management SHE&S walk-throughs are performed to help drive work-site-hazard awareness and promote supervisor/worker engagement. The program includes a "weekly hit list" for good and bad practices, including the use of pictograms, charts, bulletins, and other in-field coaching aids that are also used in task instructions and toolbox talks. The project is divided into eight principal areas, including "off-plots" with the respective Contractor area-construction manager, also known as an IIF unit leader, responsible for his/her area. He/she has "area-specific" IIF unit walk-throughs related specifically to behavioral observation and intervention at least once per week. Workers from the respective construction areas also participate in these walks. Stronger worker/supervisor/manager relationships have been a direct result of IIF unit walks.

For program oversight, the Contractor hosts monthly SHE&S management meetings with subcontractor and Company senior-project and SHE&S management to review program status and a 90-day look-ahead. Similar quarterly meetings are held with the senior-executive-management representatives from the Company, Contractor, and subcontractors. Monthly senior-management reviews are also held between the Contractor and the Company to review the recognition, budget, and disciplinary actions sitewide, with the emphasis on worker recognition and milestones for project achievements. The Contractor SHE&S hosts weekly meetings with the subcontractors to review open action items from the ATRs for

Fig. 15—Vehicle-interface-protection systems and site traffic signs.

Fig. 16—Bus-rodeo awards ceremony.

FOCUSED INSPECTION: TEMPORARY CONSTRUCTION AIDS

REFERENCE SHEET

PROJECT PROCEDURE: BF-S-B00-1620-044 Rev 2 (22 April, 2013) Title: Specification for Temporary Construction Aids. *NOTE: A 3rd Revision of the TCA Procedure is being prepared based on the results of the JGC TCA Audit held in July '13.*

DEFINITION TCA: An item that is purchased or fabricated in-house that is used to assist with a site fabrication, erection, installation or testing activity (eg. Pipe stands or spools pre-fabrication, temporary piping supports for piping erection).

DEFINITION OF CRITICAL TCA: A TCA that, in the event of its failure, may cause serious injury of personnel or damage to materials, equipment, facilities or the environment.

MARKING OF TCA's:

Example: XXX-YYY-ZZZ (aaa)
XXX means name of subcontractor (CCC, NSH, DES, QCN, GCC or PMC)
YYY means type of TCA (see table below).
ZZZ means sequential numbering starting with 001
aaa means PMC numbering (if applicable).
Example: CCC – PS – 011

TABLE (TCA CODE):

- Pipe stand = PS
- Temporary Piping Supports = TP
- Lifting Frame = LF
- Lifting frame for waste drum = LW
- Pipe trolley on rails = PR
- Testing Manifold = TM
- Testing blinds = TB
- Manbasket = MB
- Moment beam bracket = BB
- Others = OT

NAMES OF TCA CONSRUCTION COORDINATORS (BY ORGNIZATION)

- JGC:
- CCC:
- NSH:
- CB&I:
- Qcon:
- GCC:
- DESCON:

TCA COLOR CODE SYSTEM

(Applied by TCA Coordinator or his authorized deputy)

- Jan/Feb/Mar: 1st quarter = WHITE
- April/May/June: 2nd quarter= GREEN
- July/Aug/Sept: 3rd quarter = GREY
- Oct/Nov/Dec: 4th quarter = ORANGE

PROJECT TCA LISTING:

CRITICAL TCA:

- Lifting frame
- Lifting frame for waste drums
- Lifting spreader bar
- Pipe fabrication support
- Temporary pipe support
- Pipe Trolley on rails
- Testing manifold
- Testing blind
- Temp pipe spool in Steam Blowing (PMC)
- Temp Jumper Lines for LO Flushing or chemical cleaning (PMC)
- Knife Valve for Air blowing (PMC)
- Knife Valve Operating Panel (PMC)
- Vent stack for Boiler Start Up (PMC)
- Temp. restriction O Plate (PMC)
- Temp Blind (with pressure) (PMC)
- Temp. Filter and Strainer (PMC)

NON-CRITICAL TCA:

- Bridging Frame
- Cable Drum Support
- Cylinder Cage (with lifting lugs)
- Concrete blocks.
- Equipment alignment jig
- Pipe rotating tool
- Pipe stand
- Pump lifting lug
- Cable drum roller bar
- Table and Vice
- Transportation Beams/supports
- Temp. Blind (non pressure)
- Temp. pipe spool.
- Silencer for S. Blowing (PMC)
- Target plate inserter (PMC)
- Temp. Spool in Steam blow, air blowing, water flushing, Pump MTR with water, Temp Hose Manifold, Temp hose connector (PMC)
- Hopper for catalyst loading (PMC)

Fig. 17—Temporary-construction-aids (TCAs) focused-inspection reference sheet.

all incidents, audits, focused inspections, field surveys, and observations and holds a separate meeting with the Company on SHE&S program issues.

Transport and Pedestrian Safety (Man/Machine Interface). As a contract requirement, a comprehensive "man/machine interface" program for the Company, Contractor, and its subcontractors is in place that includes

- A transport and pedestrian safety program to help ensure that workers remain safe at all times (**Fig. 14**)
- An in-vehicle monitoring system for project vehicles, buses, tipper trucks, and concrete delivery trucks to track critical operating parameters
- A requirement that all project drivers complete an 8-hour defensive-driving course
- Daily alcohol testing for all vocational drivers and equipment operators
- A plant and equipment inspection and maintenance program for more than 5,000 units of plant structure and equipment that are managed through daily, monthly, quarterly, and annual inspections
- A tipper truck control program to ensure safe operation at the work site
- A bus-rodeo program to evaluate bus drivers' skills and recognize the best safe drivers
- A heavy-equipment-rodeo program for equipment operators and flagmen/banksmen to evaluate and recognize operators and flagmen/banksmen
- A vehicle-reduction program to reduce the number of small vehicles on-site, and to promote the use of the drop-off/pick-up bus service
- The traffic-violation tribunal (TVT), which is based on a point system, to adjudicate in-plant and outside-of-plant traffic safety violations (to date, more than 1,000 cases have been considered by the TVT)

The man/machine interface at site is managed through regular inspections and reviews. As such, vehicle-interface-protection systems have been installed in all site and camp bus-stop areas (**Fig. 15**). This essentially creates physical barriers between the

Fig. 18—Dark-corners inspections.

Fig. 19—2013 hand-injury-prevention campaign.

workers and buses during pick-up and drop-off times. The system has proved highly effective, ensuring that safe drop-off and pick-up is achieved on a daily basis. Traffic surveys are also performed for traffic signs, and the signs are regularly adjusted according to site requirements and the dynamic nature of the construction site.
The rodeo program is managed in different phases that include training and a practical assessment of actual skills. The driver and/or operator then receive a grading, which is captured into a database. The program is run in 12-month cycles, and the top drivers and operators are then selected and issued with prizes such as cash vouchers and return airplane tickets to the top driver's home country (**Fig. 16**).

Six Challenges

Critical Temporary Construction Aids. A critical-temporary-construction-aid (CTCA) management program is in place that helps ensure that temporary aids are designed, constructed, and used in a safe manner, including the inspection and tracking aspects of CTCAs. The temporary aids include items such as pipe stands, A-frames, and blinds. Thousands of CTCA items are now tracked and managed through this system. At project start, the management of CTCAs was challenging for the Contractor and its subcontractors to meet project requirements. However, two audits and a focused inspection have resulted in significant program improvements. The Contractor and its subcontactors each have a full-time CTCA coordinator who maintains master logs per the Contractor "process matrix" and conducts monthly audits in the field and covering relevant office records.

The system has proved to be highly effective, and past experience has proved that management of CTCAs is an area that may generate serious problems at site. The program is now fully implemented, and much awareness has been generated at site on this subject. Refer to **Fig. 17** for an example of the reference sheet for CTCA.

Craft-Skills Training. In 2012, because of a number of incidents in which deficient craft skills were identified, a review of the Contractor craft-skills training was undertaken and recommendations were identified. A revision to the Contractor site procedure was completed, and dedicated personnel were appointed, including full-time Contractor and subcontractor coordinators. A program was initiated to evaluate craft skills of site personnel and make improvements, as required (e.g., training matrix, courses).

Subcontractor construction managers are responsible for ensuring their semiskilled labor is sent for craft-skills training upon identification of a deficiency. Training compliance and effectiveness are measured through a database (on the basis of the training matrix), which provides the management process to ensure that training is conducted within scheduled time periods for workers requiring additional craft-skills training. Management reviews are performed periodically, and construction managers are held accountable for ensuring that the required training is completed. Audits are also carried out to ensure that the system functions as intended.

From these efforts, the craft-skills training program continues to be emphasized, and as such, a great improvement has been noted in the reduction of craft-related injuries. The incident analysis identifies the specific crafts that are more prevalent for injuries, and then the subcontractors focus on those crafts. Carpentry, pipe fitting, rigging, and scaffolding have been identified as crafts that are more prone to injuries project-to-date, and personnel in these crafts have received focused craft-skills training.

Dark Corners. Dark corners are areas of the project that are not as frequently inspected or visited in which hazards may lurk (**Fig. 18**). Examples of dark corners are containers, toolboxes, makeshift shelters and offices, and off-site laydown areas. Dark corners receive special focus during the management walk-through every other week, with the findings presented at the kick-off meeting of the next week's walk-through. Examples of issues identified in dark corners are damaged personal-protection equipment, machine guards removed from tools, homemade tools, and insufficient welfare facilities (ablution, rest shelters, drinking water).

Excavations. To date, there have been 17 excavation incidents of which 14 resulted in cable damage. Thus, the majority of these incidents have been grounding cables buried at a shallow depth. Three high-potential (HiPo) near-miss incidents have occurred in which an energized live electrical cable was damaged, and there was one

incident in which the cable was not yet energized. Two HiPo incidents have involved excavations into the plant fire-water pipeline that was under construction.

Because of these incidents, the Contractor has strengthened its excavation requirements to include

- Most recently issued for construction (or red-line) drawings must be attached to the permit-to-work (PTW) before approval of the excavation.
- Performing party and issuing authority on the PTW must initial the drawing attached to the PTW.
- Performing party and issuing authority must inspect the work site before issuing the permit. Failure to comply shall result in severe disciplinary action.
- Performing party and issuing authority must complete excavation competent-person training and will be issued a competent-person identification badge on completion of the training.
- Current red-line drawings are to be displayed in the Contractor PTW offices for all temporary "live" underground cables.
- Scanning of live cable is required before excavation commencement as per red-line drawing.
- Live underground cables must have unobstructed and visible "cable markers."
- Excavation must be marked (paint or chalk) per marked-up drawing before excavation begins, and access/egress points are to be indicated clearly.
- In the event an excavation is planned within 1 m of known underground facilities, hand-dug trial pits must be made to identify/expose the underground facility.
- Apart from scanning, if known underground facilities are not detected, hand-dug trial pits shall be used to locate and identify the facilities.
- For manual excavations, manual-excavation signs must be used/installed in the area in which the excavation is to be performed, and the area must be marked clearly (with paint or chalk or barricade).
- Cable-detection equipment may be used only by trained and competent persons.

As noted from the preceding list, excavation-control requirements on the project are very strict and comprehensive. Supervisors who are responsible for excavation activities must undergo awareness training on the project requirements and attend excavation competent-person training. Another tool is the use of cable-detection equipment before the start of excavations that can detect energized and nonenergized cables. The majority of incidents occurred when these tools were not used correctly or when supervision perceived the risk to be insignificant and did not take time to carry out the job correctly.

Hand Injuries. Line-of-fire hand injuries have occurred on the project, with the majority of the incidents related to pipe fitting, rigging, and scaffolding. Two hand-injury campaigns were conducted, one in 2012 and a second in 2013 (**Fig 19)**. The project's hand-injury-prevention program includes craft-skills training, awareness campaigns, on-the-job training, and TI-improvement campaigns.

The September 2013 hand-safety awareness campaign included hand-injury booths being erected at different areas at site by the subcontractors. The booths contained information such as awareness posters, examples of tools and equipment, and practical training. At the completion of the campaign, the booths were evaluated by the project's senior-management committee. The evaluation included an assessment of the contents of the booth and discussions with workers to determine the knowledge that the workers obtained during the campaign. The subcontractors also visited each other's booths to ensure that lessons from different groups were shared across all project organizations.

Lifting and Rigging. Overall, tens of thousands of lifts have been made safely on the project for steel erection and pipe and equipment installation. For "heavy lifts," more than 42,000 tons were executed without incident—the largest being two 1,400-ton, 56-m-long vessels. Another 40,000 tons of structural steel has been installed. At peak construction, more than 360 cranes were operational at site. All lifts require a lifting plan, method statement, job-safety analysis, and a PTW. All rigging and crane-operating personnel are third-party certified, and an extensive annual lifting and rigging inspection program is conducted by a third-party inspector. The Contractor and Company also have dedicated lifting, rigging, and equipment specialists who inspect the equipment regularly, and help plan and oversee safe work execution.

Nevertheless, crane-related incidents have occurred on the project, with two being the most significant:

- While shifting a 6-ton pipe spool at a fabrication shop, the lattice boom of a 70-ton crawler crane fell to the ground because of the sudden breakage of the wire rope connected to the boom hoist drum. The incident resulted in damage to the pipe spool and severe damage to the lattice boom. Fortunately, the riggers honored the lifting-exclusion zone and no injuries occurred.
- A tower crane moving a load swung its boom into the boom of an adjacent mobile hydraulic crane that had extended its boom in preparation of lift. At the time of the incident, the mobile crane was idle, with its load on the hook, but sitting on the ground and the operator sitting in the cab.

Various actions have been generated from these incidents, including special actions to manage the interface between cranes and different subcontractors, additional third-party inspections of the equipment, and evaluation of competent persons. The project has mobilized two specialist lifting and rigging companies to evaluate the equipment and personnel as part of its independent annual review of the lifting activities.

Conclusion

The project has numerous challenges, with a large workforce, multiple subcontractors, and a dynamic site. A significant investment of time and effort is being expended by many personnel to promote an incident- and injury-free workplace. The project safety culture has continued to improve since project inception through a very collaborative effort between Company, Contractor, and subcontractors. A recent major focus area has been the improvement of task instructions to ensure that safety, good quality, and production are delivered on a daily basis. The culture on the project is highly focused on the welfare of the workforce, and this approach is helping to deliver world-class results.

As highlighted in the paper, several areas are excelling and exceeding expectations; however, problem areas exist and these areas are addressed on an ongoing basis through the different systems and tools in place. Continued focus on positive worker, supervisor, and management relationships is vital to sustainable performance. Project management is highly committed to this and is also highly committed to the delivery of a world-class facility safely, on schedule, and with excellent quality. The safety, health, environment, and security (SHE&S) performance to date is the result of the collective commitment by the personnel of the Company, Contractor, and subcontractors to implement and sustain an SHE&S culture that strives to keep everyone safe on every task throughout the project life.

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