Adding Human Factor to Rig Anti-Collision Systems

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SAFETY REMAINS A paramount concern for drilling operations where a multitude of operations and equipment movements are taking place simultaneously at a rapid pace. The drill floor is a location of many activities that present safety hazards to those working within its confines.

Familiar to most are the obvious safety concerns around traditional manual methods for pipe handling, making and breaking tubular connections, handling of pipe slips, and the manipulation of tubulars and other ancillary equipment to and from the well center.

Continued improvements in drill floor design and mechanization have proven to reduce the amount of manual labor required for many of these operations while at the same time reducing the incidents of related injuries.

However, the addition of more machines and automated systems around the drilling operation have created an even more congested work environment for rig personnel who are still required to carry out manual interventions.

A benefit of modern automation being employed at the drill floor is the ability to control machines in a fully or semi automated mode to perform a variety of tasks.

Often these operations consist of repetitive cycles with the same task and movement being performed over and over, as is the case with tripping pipe, for example. The machines and their related control computers can work in harmony to complete the pre-programmed tasks without being hampered by fatigue and inaccuracies that can occur with humans performing the same job.

Since these machines are located and operating within a relatively small area, there exists the potential for machines to collide or otherwise interfere with one another.

The addition of an Anti-Collision System (ACS), tied together between the automation systems controlling each machine, is a common solution employed for ensuring automated equipment can work harmoniously in the same area.

A completely automated drilling operation free from human manual activities has yet to be completely realized.

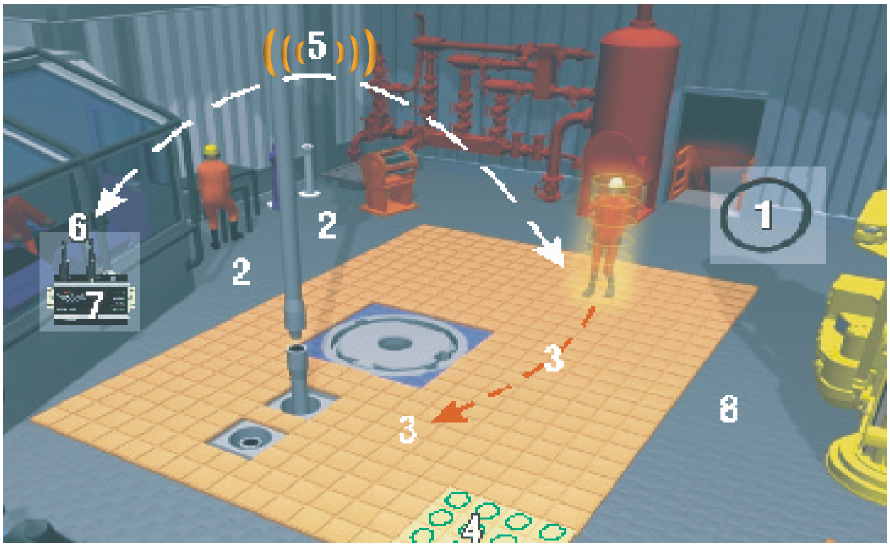
Although the industry continues to make great strides in further automating drilling activity at the surface there still exists the need for human intervention on the drill floor, even if only periodically.

Regular tasks such as equipment inspection, maintenance, and service still make it necessary for personnel to enter the drill floor area, often while drilling continues around them.

Commonly, rigs that operate with a variety of automated systems will continue to have some processes completed manually, creating a drill floor that is a mix of automatic or mechanized and manual or human activities. Herein lies the potential hazard for accidents and injuries.

The next logical step is to employ technologies that allow the human entity to be incorporated into the rig's anti-collision system. By being able to identify the presence and movement of personnel on the drill floor, there is an opportunity to take a proactive approach to avoiding injuries caused by accidental man-machine collisions, thereby increasing safety and rig efficiency.

This protection for personnel can be additionally applied to other areas of the drilling installation such as at the pipe deck, within crane operating areas, and other various work platforms and locales.



The basic elements of the system and their respective locations on atypical drill floor installation include (1) Passive Ring Transponders, each with their own unique ID embedded in safety floor mat material (each floor mat segment is 3.28 ft. (1.0 m) square); (2) less exposed zone occupied by drilling crew (Doper); (3) Tracking of workers; (4) passive transponders on the floor (shown as a grid of green circles above). The entire yellow area is covered by customer built transponder mats fixed to the floor; (5) wireless communication (radio link) to and from workers; (6) Radio Antenna; (7) Radio Base Station with interface to ACS in safe area; and (8) potential danger zone for workers outside monitored mat area.

BASIS OF THE SYSTEM

The theory of this safety enhancement system is to add active location monitoring of humans working in the same area as automated equipment.

Although human movement cannot be predicted and anticipated in advance, it is possible to limit machine movement and activity when that equipment reaches an area occupied by a human worker, thus preventing potential collision injuries.

SYSTEM DESCRIPTION

A Human Entity Protection System (HEPS) utilizes proven wireless technology in order to integrate the human element into the drilling machinery ACS for a safer, more efficient drilling operation.

Candidate drilling installations for HEPS are those that employ automated machines that are controlled by central computers.

In order for HEPS to be effective, it is essential that the rig's automated machines, equipment, and controlling computers are capable of supporting an anti-collision system (if an ACS is not already in place) to which HEPS can be added.

The HEPS system utilizes relatively simple and reliable radio frequency technology to identify and track the location of personnel within a defined area.

The basic elements of the system and their respective locations on a typical drill floor installation are:

• Passive Ring Transponders, each with its own unique ID embedded in safety floor mat material (each floor mat segment is 3.28 ft. (1.0 m) square);

• Less exposed zone occupied by drilling crew (Doper);

• Tracking of workers;

• Passive transponders on the floor;

• Wireless communication (radio link) to/from workers;

• Radio Antenna;

• Radio Base Station with interface to ACS in safe area; and

• Potential danger zone for workers outside monitored mat area.

Passive transponders are placed within a series of protective floor segments. The floor segments are placed together in the work area to be monitored, creating a safety mat with complete coverage.

These transponders are passive (coil and chip with a unique ID) and therefore contain no batteries nor require any connecting cables.

Personnel on the drill floor wear a rechargeable battery operated transponder reader that is encapsulated inside specially provided safety footwear (only one shoe or boot has the reader installed) or alternatively the reader may be worn as a strap-on device at the ankle.

Using radio communication, the reader transmits any transponder positions in real-time to a radio base station.

One base station monitors up to 14 persons simultaneously.

The host system accommodates up to 64 users onboard a rig or vessel. Multiple base stations may be used to protect additional personnel in other areas, or in the event system redundancy is desired.

Using Radio Frequency Identification (RFID) technology, installing and configuring the HEPS system is accomplished by installing the required mat segments on the drill floor and identifying the area and its coordinates from a layout drawing.

This process maps the mat segments with their corresponding location into the host system software.

Since the embedded transponders each possess a unique identification, the system is able to determine the exact position of each transponder.

The system monitors and compares movement of personnel and machines on the X and Y-axis.

Future development includes adding the movement of machines and objects on the Z-axis, with special attention to overhead equipment and potential for falling objects in areas where personnel may be located below.

When someone with a reader in his or her footwear steps onto the mat, the HEPS along with the ACS knows exactly where that person is positioned.

The system then compares the worker's position to that of machinery operating in the same area and can limit the machine's movement to prevent coming within a predetermined safety radius around the worker.

With HEPS employed, the system would send a halt command to the equipment, maintaining the safety radius around the worker.

DESIGN CRITERIA

Where possible, proven "off-the-shelf" industrial components are utilized. The industrialized version of HEPS is built according to relevant IEC standards (e.g. IEC61508) and regulations for EEx & EMC requirements as well as conformity to communication standards.

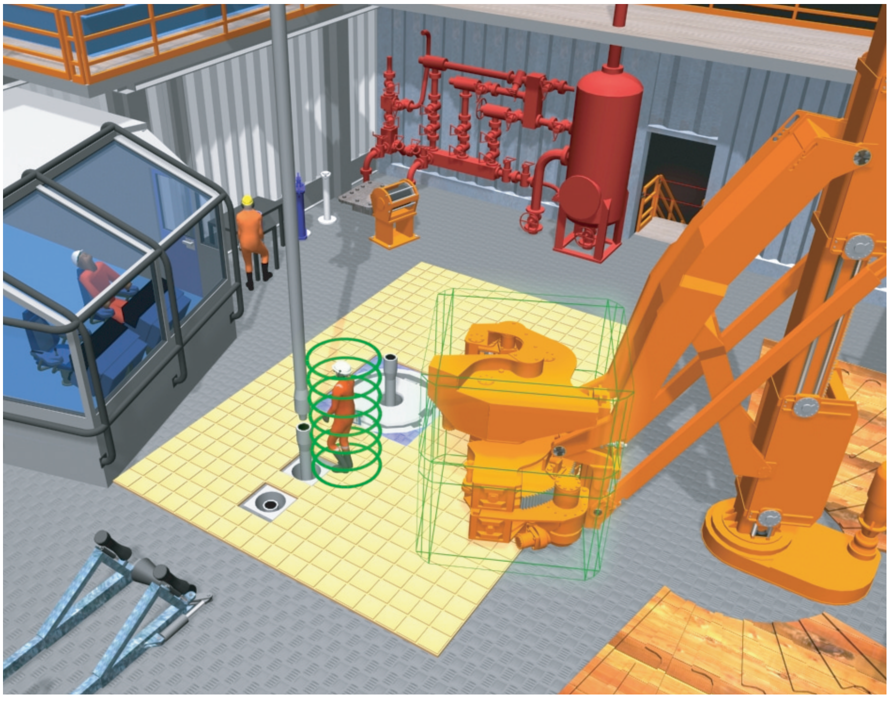
As a safety enhancement system, HEPS is additionally designed with a fail-safe element that causes the rig's ACS to send a halt command to all machines in the event of an error in HEPS communication or similar condition where personnel tracking may be lost.

This fail-safe situation must be manually reset once the error in the system has been resolved.

PERFORMANCE INFORMATION

The RFID technology used in HEPS allows for crew tracking accuracy within 6.89-in. (175 mm) nominal from the located transponder. Each molded transponder has a predefined "physical" location inside its mat segment.

The system operates in real-time, updating personnel position every 100 milliseconds (nominal). Machinery halt response is less than 100 milliseconds (to send halt command to the machine's control system).



The safety radius around workers and the monitored envelope around machines and equipment are indicated by green lines in the illustration above.

HEPS has been developed to meet Zone 1 (EExim) area classification requirements.

APPLYING THE SYSTEM

The HEPS system is designed as a proactive rather than reactive tool that constitutes a supplement to the local machinery shut down systems and existing HSE procedures for a given drilling installation.

Numerous machine activities around the drilling operation pose the potential for accidents and serious injury to personnel working around the drill floor. Types of injuries that can be prevented by HEPS include:

- Crew being pinched or crushed by a machine;
- Crew becoming caught between several machines;
- Crew being hit by a moving machine;
- Injuries caused by crew trespassing into an machine activity area;
- Fatal injuries caused by lifting operations;
- Injuries caused by unsuitable operational modes; and
- Consequential damage and injuries from machine collisions.

A number of drilling activities have been studied for the ability of HEPS to increase safety and efficiency factors.

The following are specific types/areas of operations with inherent man-machine collision risks that also have a significant impact on drilling efficiencies:

- Dual operations/double derricks;
- Iron Roughneck travel between parked and well center positions;

Personnel on the drill floor wear a rechargeable battery operated transponder reader that is enclosed inside specially provided safety footwear. The transponder can also be worn as a strap-on device at the ankle.

• Casing Roughneck travel between parked and well center positions;

• Casing Tongs makeup / breakout operations (manual operation);

• Pipe Handling Systems pick-up and lay-down movements to and from the pipe deck/catwalk to well center;

• Horizontal-to-Vertical machines moving pipe into the well center;

• Pipe Conveyor sequences moving tubulars from pipe deck into the well center;

• Pipe Handler movements at the drill floor;

• Top Drive/elevator link movements;

• Top Drive raising/lowering in Derrick;

• Special operations (well control operations, BHA deployment, service operations, etc.);

• Manual doping operations;

• Manual handling of pipe slips;

• Manipulator arm movements;

• Raised backup systems;

• Extra mouse hole operations;

• Riser handling from storage to well center location;

• Derrick utility baskets; and

•Monkey/casing stabbing board areas.

TESTING THE PROTOTYPE

Factory testing of the HEPS prototype was carried out by setting up a test "drill floor" complete with a series of safety mat segments installed around an imaginary well center.

Actual automated machinery was employed to test the response times and actual performance of the system when integrated into a machine's ACS.

Tests were performed using a prototype transponder reader mounted in a boot.

As the wearer moved across the safety mats, the system automatically detected the proximity of the reader and relayed the information to the ACS.

An indication of the person's position and movement was tracked on a screen in a similar fashion to a computer's mouse causing a pointer to move on the screen.

An iron roughneck was then started in an automated sequence where it would move towards the well center.

As designed, once the iron roughneck reached the safety radius of the test worker the ACS delivered a halt command to the iron roughneck. Further tests with various other scenarios have proven to be highly successful.

Efficiencies can be taken into consideration when installing and customizing the HEPS systems for a particular drilling operation.

The halt command received by a machine can be followed by a programmed "pause" for a period of time before the machine can resume its automated sequence only after the person has left the operating vicinity.

It is also possible to completely cancel the sequence, requiring a manual restart command from the driller.

These variables must be carefully considered when integrating the HEPS with the rig's ACS to ensure the highest levels of safety while taking advantage of the HEPS ability to augment automation efficiency.

FUTURE APPLICATIONS

Monitoring machine and human interaction at the drill floor level is initially concentrated on the horizontal X and Y-axis but many overhead operations take place above the floor.

It is possible to add the Z-axis to HEPS in order to provide monitoring of overhead systems such as pipe racking machines, top drives, traveling equipment, and various hoisting components.

By adding the third dimension to HEPS it is clear we can achieve even greater improvements in safety and operation efficiency can be achieved.