

DESIGNING FOR SAFETY – HOW TO DESIGN BETTER WATER TREATMENT WORKS

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The paper describes the initiatives that have taken place in a large water utility Company – United Utilities plc, to improve the safety of new water and wastewater treatment works. These initiatives were designed to improve the standards of safety for personnel during the operation and maintenance of the assets. The focus of the initiative was to ensure that the entire project team understood the hazards and difficulties created by not considering operational and maintenance safety throughout the development of the project. This was a quality improvement initiative that produced safer treatment works.

KEY TERMS: Designing for Safety, Safer by Design, Operation, Maintenance, Quality, Construction.

1. INTRODUCTION

The water industry is set challenging targets by its regulators, and achieving those targets stretches the delivery teams. Historically, the delivery of the capital programmes was fragmented, with none of the client, design, construction and operation (client) teams being actively involved throughout the process. Consequently, the views of parts of the team may have been overlooked, and hazards built into new projects. Because of the fragmented nature of the delivery, the whole project team did not always learn the lessons, and the same hazards were repeatedly identified on a number of projects. In pre-handover inspections of newly constructed works occupational health and safety specialists identified commonly occurring faults that could have been identified earlier in the design and construction process. These faults were expensive and difficult to resolve retrospectively. In order to remedy this, it was necessary to close the feedback loop, and allow the whole project team to see for themselves, and to learn from these hazards.

A programme was developed to raise the awareness of the project teams. This started as a series of presentations, showing photographs of the commonly occurring hazards. This developed into ‘designing for safety workshop tours’ of the best water and wastewater treatment works, and then finally a series of “discovery tours” were held. The Company, designers and the project teams adopted improved practices that resulted in safer treatment works. Treatment works constructed presently now have far fewer built-in problems that make the works easier to operate and maintain and are consequently safer.

The project management triangle comprises of the elements of cost, quality and time. In the majority of projects emphasis is given to cost and time in getting the project completed to budget and on time due to the commitments given to the regulator in satisfying

regulatory requirements. The quality focus in this case is to meet regulatory standards for water. Frequently the quality element of the projects itself is more difficult to measure and is often relegated to the ‘post-mortem’ operational stage of the project when the key participants have moved onto their next project.

2. BODY

2.1 THE PROBLEM

When new water or waste water treatment are constructed a formal safety inspection is performed by an occupational health and safety specialist as part of the commissioning process to identify any remaining hazards that need to be addressed and resolved prior to handover to the Company. It was identified by the occupational health and safety specialists that the problems identified were repetitive.

Examples of these problems were as follows.

- a. changing lights bulbs. (Picture 1 – problem, Pictures 2–3 solutions)
- b. the cleaning and replacement of ultrasonic level sensors. (Picture 4 – problem, Picture – 5 solution)
- c. fixed lifting equipment unable to lift and move equipment to a set down point or lorry.
- d. unsafe manual handling tasks with heavy weight and difficult journeys. (Picture 6)
- e. safe access to under floor equipment.
- f. accessing high level workplaces with a tool kit.

2.2 THE SOLUTION

It was decided that it would be beneficial to gather the client representatives together with the designers and constructors of works together and make them aware of the commonly occurring problems. Three approaches were used:-

2.2.1 Approach one

The meetings were of a two-hour duration and were attended on each occasion by thirty participants comprising Directors, Construction Managers and Design Engineers in the Company and Partner Organisations. A total of sixty key players attended these events. The presentation lead by a health and safety specialist took the following format

- Introduction – to establish the attendees engineering background knowledge and their experience of designing and constructing water and wastewater treatment works.
- Outline of legislation – to understand the legal requirements.
- Presentation showing photographs of good and bad design and the safety implications.
- Discussion, and Summary

Many of the attendees expressed surprise that such hazards had not been identified and designed out prior to construction. One expressed amazement at the “schoolboy howlers”.



Picture 1. How easy is it to change this light bulb?

Senior management agreed that steps should be taken to ensure that improvements were made, and agreed to sponsor a series of site tours for the project teams that lead to Approach 2.

2.2.2 Approach two

After these initial ‘awareness raising’ events it was decided to take the project teams to sites to see water and wastewater sites that had recently been constructed. (Picture 7) These ‘see for yourself’ tours for the project teams took place on newly completed treatment works. Parties of twenty to thirty designers were shown around the works showing them the difficulties in operation and maintenance that can result from poor design. Experienced Process and Maintenance personnel were present on the tour, and they were able to handle detailed questions. This enabled the message to be given to a much larger audience which enabled greater numbers to be briefed (around 150).



Picture 2. This light bulb can be easily replaced

2.2.3 Approach three

The third step was to hold 'discovery' tours. These were held for between eight and fifteen attendees from one organisation or project team. The structure differed from previous tours with the emphasis changing from the attendees being told what was wrong on new works to more of a 'voyage of guided discovery' where they were split into two groups and taken to twelve pre-identified locations on the works. The attendees were challenged to identify good



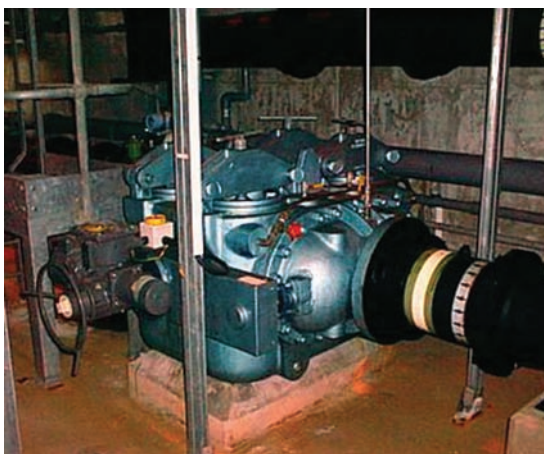
Picture 3. These light fittings descend from the ceiling so that the light bulb is easily replaced



Picture 4. These ultrasonic sensors accumulate spiders and cobwebs and are difficult to clean and replace



Picture 5. Ultrasonic sensor with hinge



Picture 6. This strainer lid weighs in excess of 20 kg and is in a constricted location – how can it be lifted?



Picture 7. Designers ‘seeing for themselves’ the works that ‘we made earlier’

and bad aspects of the design and construction. The tours were lead by safety, operational and maintenance experts also acting as facilitators to ensure that no pertinent points were missed. The delegates returned to the meeting room to discuss what they had found. There was ‘a buzz’ – after all what was being examined and scrutinised was our best water treatment works. The delegates had not constructed the works and consequently were not responsible for the



Picture 8. Lostock Water Treatment Works – our best water treatment works! Ultrasonic level sensor – how is it cleaned and replaced?

design faults. This allowed free discussion of the good and bad points that had been identified. Each team produced a list of frequently occurring faults and this was structured and prioritised into a 'hit list' of problems to avoid during the construction of new treatment works. These lists were used as 'lessons learnt' prompt sheets for future projects and subsequently incorporated into the Access, Lifting and Maintenance Review Procedure.

This was the most successful of the three approaches. Due to the group size the groups formed much more of a team mindset in trying to spot the strength and weaknesses. Elements of game-playing and competition were introduced which brought out the 'fun' element which is not normally associated with a safety training event. It was turned into a game – people are relaxed when playing a game and are open to new ideas. It was fun. This event seemed to spark the team into becoming better designers.

Case Study – Lostock Water Treatment Works

The project team for Lostock Water Treatment Works (Picture 8) attended a "discovery tour" of 'Approach Three' type sessions. The priority problems were identified and meetings were held to debate and agree the way forward. As a result of these tours the following events happened:-

The team revisited the site to 'ask questions' and 'tap into the knowledge' of the process controllers. They visited several other similar sites to learn from others – they were determined to improve on previous sites. As a result of these initial activities the Team was awarded the first 'Designing for Safety Award' from the Company in recognition of their active commitment to the subject. The works, supplying safe drinking for 500,000 people in Greater Manchester, was built and due to the exceptionally high standard of the design and construction the construction team received a further 'Designing for Safety Award'.

2.2.4 The 'Designing for Safety' seminars were repeated in following the approach three format and the following outputs occurred:-

- a. A CD-ROM self-learning package was produced with the key learning points. This took the form of several PowerPoint Presentations on Designing for Safety based on the most important learning points of the tours. This was issued to the partner organisations and their design teams.
- b. A lifting, access and maintenance review was brought into the design process to consider the common problems in a 'HAZOP' type' approach. This also requires that any lifting equipment must be demonstrated to be proved 'fit for purpose' prior to handover.
- c. Designing for Safety Working Group re-convened and new edition of the Company Designing for Safety Document was issued.
- d. The Company became more conscious and demanding in its needs for quality on new works. Improved 'signature' or model designs were developed and used as 'building blocks' for project specific designs. There was also greater involvement of the

- operators and maintainers in the safety inspection at the pre-handover inspections and earlier in the design process.
- e. Designing for Safety Awards were issued for the Company programme of work to Companies that had demonstrated commitment and competence in designing and building better works.
 - f. Designers used 3D – design software with operators prior to construction on a project.

3. RESULTS

The new water treatment works produced by the focus team was by far the safest that had been produced to date. Improvements have been seen on the majority of projects. Those projects where hazards are identified at the pre-handover stage are now flagged for investigation to the Engineering Department. They can then take any necessary steps to ensure that the processes are modified and to ensure learning. Overall, the amount of snagging and corrective work has reduced – reducing costs, and the works that are built are safer to operate and maintain.

4. DISCUSSION

Delivering a safe new treatment works, needs the involvement of the whole team – from good specification, and standards, good outline and then detailed design, to diligent construction and commissioning and then provision of feedback to the whole team about the safety of operation and maintenance. If the construction team are instructed about hazards that should have been designed out in the design phase, or the snagging team are informed of hazards that have not clearly been specified by the client, then appropriate learning cannot take place.

Just as no one wishes to have an accident – everyone would like to do a good job. Good engineers are problems solvers and solution providers – give them a challenge and they can rise to it. After all it was engineers who put a man on the moon.

The Institution of Civil Engineers website currently states in a promotion of engineers “When you understand civil engineering, you see the world differently” The truth is we all see the world differently, sometimes, safer design and construction comes through seeing the world through another persons eyes – the operators!

5. CONCLUSIONS

Unless an effective feedback loop is established throughout the delivery process, lessons will not be learned, and the same mistakes may be repeated. In a delivery process that engages a number of different organisations, it is more difficult to ensure that feedback is given to the appropriate team members throughout the design and construction process.

On all treatment works the standard of completed treatment works that we now have built is much higher than when we commenced this approach in 2000.

Awareness has increased with all the approaches used and the construction team is now aware of the need for designing for safety.

The works are easier to maintain and operate.

'Designing for Safety Awards' act as a useful incentive that can be issued by the Client and can be used to advertise the success of the Project Team in promotional material on their Company websites (see Internet links).

6. RECOMMENDATIONS

This entire initiative promoted a learning approach with the project team. It was vital to raise awareness of senior management with Approach One. Approach Three was more successful than Approach Two because 'Team Learning' and peer group pressures to perform were present.

Use Company documents to support needs and preferences – signature designs, asset and company standards. Some preferences are not obvious to designers e.g. – we don't like 'ships ladders'.

Designers and constructors should always visit previous works to understand from the operators and maintainers the lessons learnt from the operation and maintenance of similar projects. This can form part of their continuing professional development.

Recognition and reward are useful incentives – good designers should be recognised and they should receive 'Designing for Safety Awards' for good practices. After all everyone remembers the 'Diane Memorial Fountain in Hyde Park and the wobbly Millennium Bridge but when was the last time a designer received praise and recognition?

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AWARDS GIVEN BY UNITED UTILITIES

Two awards for Safety in Design at Lostock Water Treatment Works to a team comprising Costain Ltd – Principal Contractor, MWH & Haswell Consulting Engineers – Designers.