WSH INNOVATION AWARDS 2017 (MANUFACTURING)
Team: Hercules - Keppel DHCS Pte Ltd
Project: Multi-Purpose Lifter
Project Team

Wong Toon Soon
Senior Manager (Sponsor)

Brian Koh
Engineer (Team Leader)

Edmund Chan
Manager, HSE (Facilitator)

Lee Thiam Hee
Senior Principal Operations Specialist (Team Member)

Micheal Wong
Senior Principal Operations Specialist (Team Member)

Vinson Siau
Executive (Team Member)

Eric Wong
Koolink (Team Member)
## SAFETY PROJECT SUGGESTIONS

<table>
<thead>
<tr>
<th></th>
<th>Ease of implementation</th>
<th>Cost</th>
<th>Safety Benefits</th>
<th>Total</th>
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<tr>
<td>Motor Winch for Cooling Towers (Lifting)</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Window Sealing Device (IPP)</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Door Sealing Device</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td><strong>Modified Sump Pump &amp; Manhole Opener / Rescuer (Multi-Purpose Lifter)</strong></td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Flexible U-Belt Valve Key System with Pole Mounter</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Chemical Pump Line</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

*The scale for each column ranges from 1 (Poor) to 5 (Great).*
Keppel District Heating & Cooling Systems
Keppel DHCS District Cooling System

District Heating Cooling System Schematic Diagram
Our Portfolio – Changi Business Park
Project Background

Routine Chamber Inspections

• In districts served by Keppel DHCS plant, plant Operation Specialists (OS) have to manually open manhole covers and access the manholes.
Project Background

1. Insert manhole cover key into manhole cover and twist it into position

2. Manually lift up manhole cover and place it by the side (2x30kg)

3. Set up sump pump and place into bottom of manhole to drain out water

4. Upon job completion, remove sump pump

5. Manually lift up manhole cover and place it back into closed position
Hazards Involved

Manual Lifting

- Manual work
- Risk of Musculoskeletal Injuries
- Risk of falling
- Dropping heavy object
Hazards Involved

Setting of equipment
- Risk of falling object
- Equipment failure

Manhole Entry
- Falling from height
## Risk Assessment (Before Implementation)

<table>
<thead>
<tr>
<th>Work activity</th>
<th>Hazard</th>
<th>Possible Accident/Ill Health &amp; Person-At-Risk</th>
<th>Existing Risk Control</th>
</tr>
</thead>
</table>
| Opening / closing of manhole cover using manhole cover key | Improper body posture & Heavy Load | Musculoskeletal injuries                       | - Adopt proper body posture  
- Deploy sufficient manpower for work                                                                                                                  | 2  | 2  | 4  |
| Manual lifting of manhole cover (opening / closing) | Falling object                  | Bodily injuries                               | - Wear appropriate safety shoes  
- Avoid having body parts below load  
- Ensure proper communication between workers                                                                                                          | 4  | 2  | 8  |
| Hoisting of sump pump                              | Person falling into opening     | Fatality                                      | - Conduct safety briefing before work commencement  
- Ensure proper footing / positioning  
- Adopt proper lifting posture                                                                                                                          | 5  | 2  | 10 |
Causes Identification (Cause & Effect Diagram)

Adverse effects during opening of manhole cover and sump pump draining
## Causes Validation

<table>
<thead>
<tr>
<th>Factors</th>
<th>Reasons for validation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heavy Loads</strong></td>
<td>• Lifting of manhole covers required in the process</td>
</tr>
<tr>
<td></td>
<td>• Can result in injuries if handled improperly</td>
</tr>
<tr>
<td><strong>Manhole exposed opening</strong></td>
<td>• Exposure to falling from height, or falling objects into the depth of the chamber</td>
</tr>
</tbody>
</table>
...or objects falling into...
# Solution Selection

<table>
<thead>
<tr>
<th>Factors</th>
<th>Solution</th>
<th>How it is done</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Loads</td>
<td>Leverage</td>
<td>• Levers or gears&lt;br&gt;• Small effort to move bigger load&lt;br&gt;• Mechanical advantage</td>
</tr>
<tr>
<td>Manhole exposed opening</td>
<td>Portable Barricade</td>
<td>• Barricades are set up around the exposed manhole&lt;br&gt;• Warn and prevent passers-by from coming near</td>
</tr>
</tbody>
</table>
## Solution Selection

<table>
<thead>
<tr>
<th>Design</th>
<th>Heavy Loads</th>
<th>Manhole opening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheel Lifter Type</td>
<td><img src="Wheel_Lifter.png" alt="image" /></td>
<td><img src="thumbs_up.png" alt="thumbs_up" /> <img src="thumbs_down.png" alt="thumbs_down" /></td>
</tr>
<tr>
<td>Winch Lifter Type</td>
<td><img src="Winch_Lifter.png" alt="image" /> <img src="Manhole_Guard.png" alt="image" /></td>
<td><img src="thumbs_up.png" alt="thumbs_up" /> <img src="thumbs_up.png" alt="thumbs_up" /></td>
</tr>
</tbody>
</table>
## Solution Selection

<table>
<thead>
<tr>
<th>Design</th>
<th>Safety</th>
<th>Ease of usage</th>
<th>Purpose</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheel Lifter Type</td>
<td>Eliminates manual lifting</td>
<td>Easy</td>
<td>One (Manhole cover)</td>
<td>(11)</td>
</tr>
<tr>
<td>Score:</td>
<td>(4)</td>
<td>(5)</td>
<td>(2)</td>
<td></td>
</tr>
<tr>
<td>Winch Lifter Type</td>
<td>Eliminates manual lifting</td>
<td>Easy</td>
<td>Multi (Manhole cover + barricade)</td>
<td>(14)</td>
</tr>
<tr>
<td></td>
<td>Physical Barricade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score:</td>
<td>(5)</td>
<td>(5)</td>
<td>(4)</td>
<td></td>
</tr>
</tbody>
</table>
Solution Development

1. Frame Dimensioning

2. Bracket Conceptual
Solution Development

3. Final Design
Solution Implementation
Solution Implementation
(Purpose #01 - Manhole Cover Opener)
Solution Implementation
(Purpose #02 - Manhole Barricade)
Solution Implementation
(Purpose #03 - Sump Pump Placement)
Solution Implementation
(Purpose #04 – Confined Space Rescue)
Hierarchy of Controls

- **Elimination**: Physically remove the hazard
- **Substitution**: Replace the hazard
- **Engineering Controls**: Isolate people from the hazard
- **Administrative Controls**: Change the way people work
- **PPE**: Protect the worker with Personal Protective Equipment
# Risk Assessment (After Implementation)

<table>
<thead>
<tr>
<th>Work activity</th>
<th>Hazard</th>
<th>Possible Accident/Ill Health &amp; Person-At-Risk</th>
<th>Existing Risk Control</th>
<th>Severity</th>
<th>Likelihood</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pushing of MPL towards location</td>
<td>Heavy load (30kg)</td>
<td>Musculoskeletal injuries</td>
<td>- Buddy system</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Briefing conducted before work commencement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening / closing of manhole cover using MPL</td>
<td>Swinging load</td>
<td>Foot injury</td>
<td>- Briefing conducted before work commencement</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Keep feet outside of MPL cage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Lock wheel before lifting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hoisting of sump pump</td>
<td>Person falling into opening</td>
<td>Fatigue</td>
<td>- Conduct safety briefing before work commencement</td>
<td>5</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Adopt proper lifting posture</td>
<td></td>
<td></td>
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</table>

**Hazard Eliminated**
Tangible Benefits

- Mechanical advantage
  - Gear ratio = 3, Lever ratio = 6
  - Mechanical advantage = $3 \times 6 = 18$
  - Load produced can be up to 18 times of effort

- Cost prevention due to fines

  General penalties

  50. Any person guilty of an offence under this Act (but not including the regulations) for which no penalty is expressly provided by this Act shall be liable on conviction —

  (a) in the case of a natural person, to a fine not exceeding $200,000 or to imprisonment for a term not exceeding 2 years or to both; and

  (b) in the case of a body corporate, to a fine not exceeding $500,000,
Elimination of costs from fines
Ariel TEE [KCL-GCC], 8/8/2017
Intangible Benefits

- Reduce the risks to
  - Worker falling from height
  - Falling objects
  - Back injuries
  - Hand & Foot injuries
  - Musculoskeletal disorders

- Outweigh manpower and large effort needed

- Lifting equipment is verified and endorsed

- Increase worker confidence level

Safer And Better Working Environment
<table>
<thead>
<tr>
<th>AT[2]</th>
<th>Increases workers' confidence levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ariel TEE (KCL-GCC), 8/8/2017</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AT[3]</th>
<th>Reduced effort and manpower needed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ariel TEE (KCL-GCC), 8/8/2017</td>
</tr>
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</table>
Standardization

ISOMETRIC VIEW
SCALE = 1:75

NOTE:
- ALL THE DIMENSIONS ARE IN mm
- MAXIMUM LOAD CARRIED BY WINCH IS 200 kg
- HOT FORGED S45C STEEL SHALL BE USED
- ALL THE CONNECTIONS SHALL BE FULL WELDED OTHER WISE MENTIONED
- MEMBER SIZES:
  - SBS 20 x 20 x 3
  - RHS 25 x 25 x 3
  - PLATE 10 mm
  - ROD 8 mm
  - PLATE 25 x 3

DETAIL - A
SCALE = 1:10

DETAIL - B
SCALE = 1:10

DETAIL - C
SCALE = 1:10

DETAIL - D
SCALE = 1:10
With an innovative solution for lifting of manhole covers, Hercules reduced potential musculoskeletal injuries and risks of falling from height. By using a multi-purpose lifter that is endorsed by a Professional Engineer, a 60kg cover would only need about 3.5kg of effort to be lifted.

Image A: Usage of multi-purpose lifter to lift manhole cover
Image B: Engineering drawing of multi-purpose lifter
Solution Review

Leg Guard
Thank You