Designing for Safety

Leading a Safety-First Culture in Working at Heights

Work at Heights Symposium 2025 - Singapore

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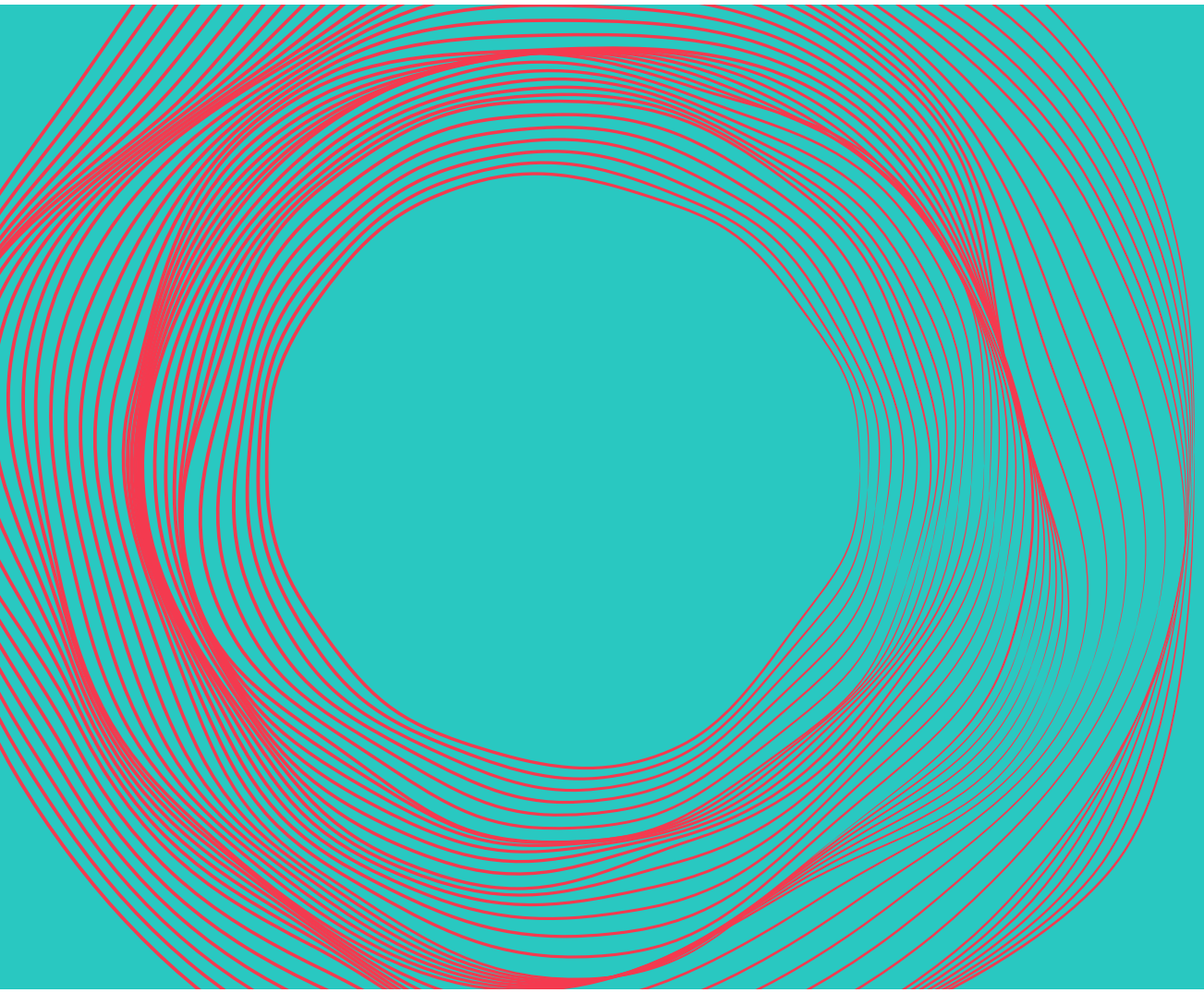
18 March 2025

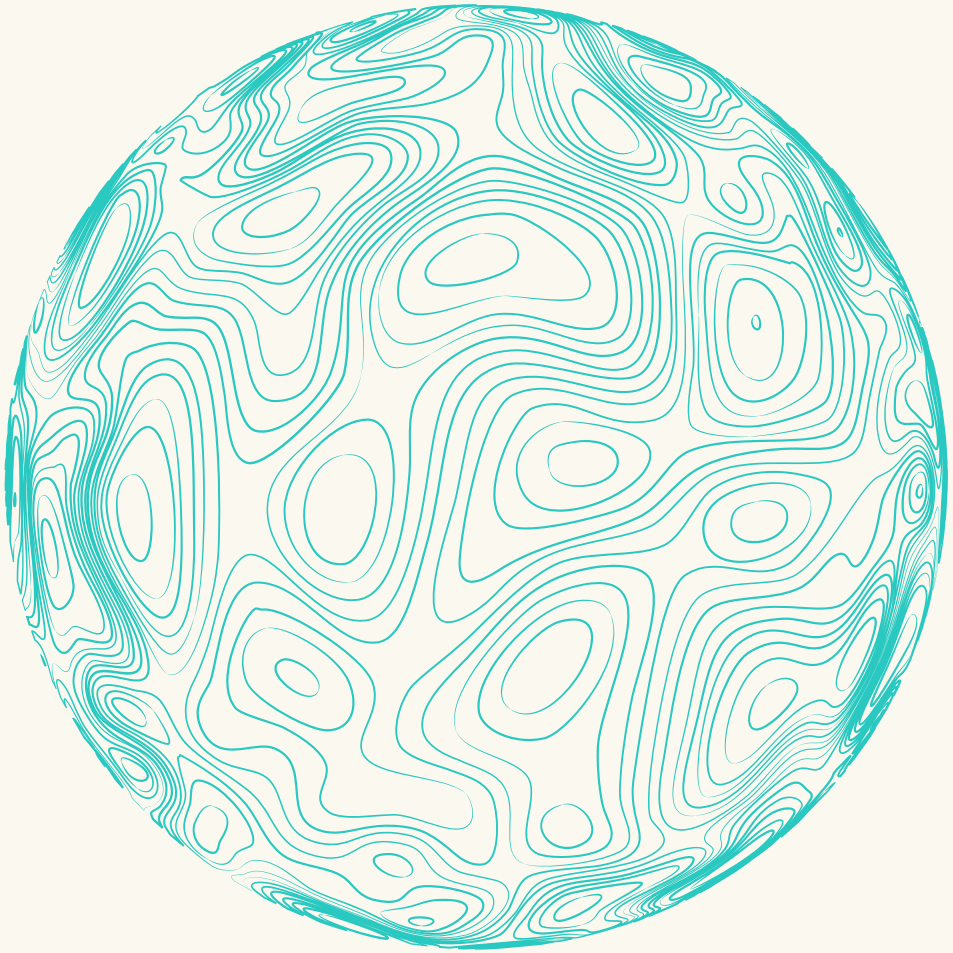


Working at heights requires a proactive, lifecycle-oriented approach to safety.

Safety-in-design principles play a pivotal role in significantly mitigating risks associated with working at heights.

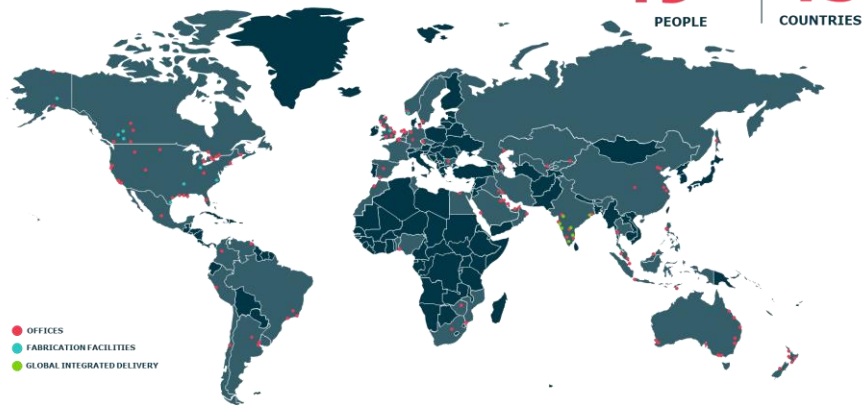
Key focus will be on Worley's **SEAL (Safe and Sustainable Engineering for Asset Life Cycle) framework and Worley Safety in Design (SiD) Standards**, which are instrumental in embedding safety throughout the entire lifecycle of an asset.

Overview Of Worley



Our global presence

49K+ PEOPLE | 45 COUNTRIES



We're with you every step of the way

We plan, create, sustain and enhance your operating assets

	Consulting and Feasibility	Engineering (pre-FEED/FEED)	EPC, EPCM, PMC	Operations and Maintenance	Late-life and decommissioning
worley consulting **Consulting & Advisory**	Strategy transaction services (M&A, DD during life of assets) Feasibility & Master Plan		Lenders and/or Owner's advisory services	Operations consulting and advisory services	
worley **Engineering services, Major Projects, Integrated & Digital Solutions**		Engineering	EPC / EPCM PMC Supply Chain Management Brownfield projects Operational readiness Production optimization	Asset management Duty holder Shutdown management	Decommissioning
	Digital and technology solutions (life of asset)				

Our Strategic Portfolio

Sustainability Pathways Decarbonization • Resource Stewardship • Asset Sustainability • Environment and Society

Our core markets

Evolving our core markets as we support our customers with the energy transition

Our growth markets

Accelerating sustainability-focused growth markets in emerging areas

Sectors

Low-carbon Energy

- Integrated gas
- Nuclear power
- Power networks
- Low-carbon hydrogen
- Renewable energy

Conventional Energy

- Upstream
- Midstream energy infrastructure
- Combustion energy
- Carbon capture use and storage

Chemicals and Fuels

- Chemicals
- Refined fuels
- Specialty chemicals
- Sulphur recovery
- Low-carbon fuels
- Plastics recovery

Resources

- Base metals
- Bulk commodities
- Fertilizers
- Resource infrastructure
- Energy transition and battery minerals
- Industrial water
- Metals recovery

Environment & Sustainability

- **Industrial hubs**
- **Adapting existing assets**
- **Sustainability and decarbonization advisory**
- **Environmental and social consulting**

Singapore Operations

Diversified business across **all project phases** and customer sectors, with a **Midstream/Downstream focus**

Southeast Asia Footprint – end to end services

Economic Analysis through Commissioning

Talent Pool of

1,991 persons | **6** countries

Thailand 287
Upstream, Infrastructure, Power, Chemical

Malaysia 1,042
Upstream, Infrastructure, Power, Chemical

Singapore 400
Chemical, Refinery, Upstream, Infrastructure, Power, Resources

Philippines 8
Upstream, Downstream, Infrastructure Power

Brunei 66
Upstream, Infrastructure, Power

Indonesia 188
Upstream, Infrastructure, Power, Chemical, Refinery, Minerals & Metals

Maintained and strengthened core team to retain leadership position in Singapore and the region

Offering Full Services

- Feasibility/ Conceptual
- Pre-FEED/ FEED
- Detailed Engineering
- EPCM
- Global Sourcing
- Procurement Management
- Construction Management
- Permitting/ Authority Approvals
- Commissioning & Start-up
- PMC, iPMT
- Safety& Risk

Serving Diverse End Markets

- Chemicals
- Refining/ Petrochemicals
- Building & Infrastructure
- Upstream & Midstream
- Power & New Energy
- Digitalization
- Mining, Minerals & Metals
- Subsea

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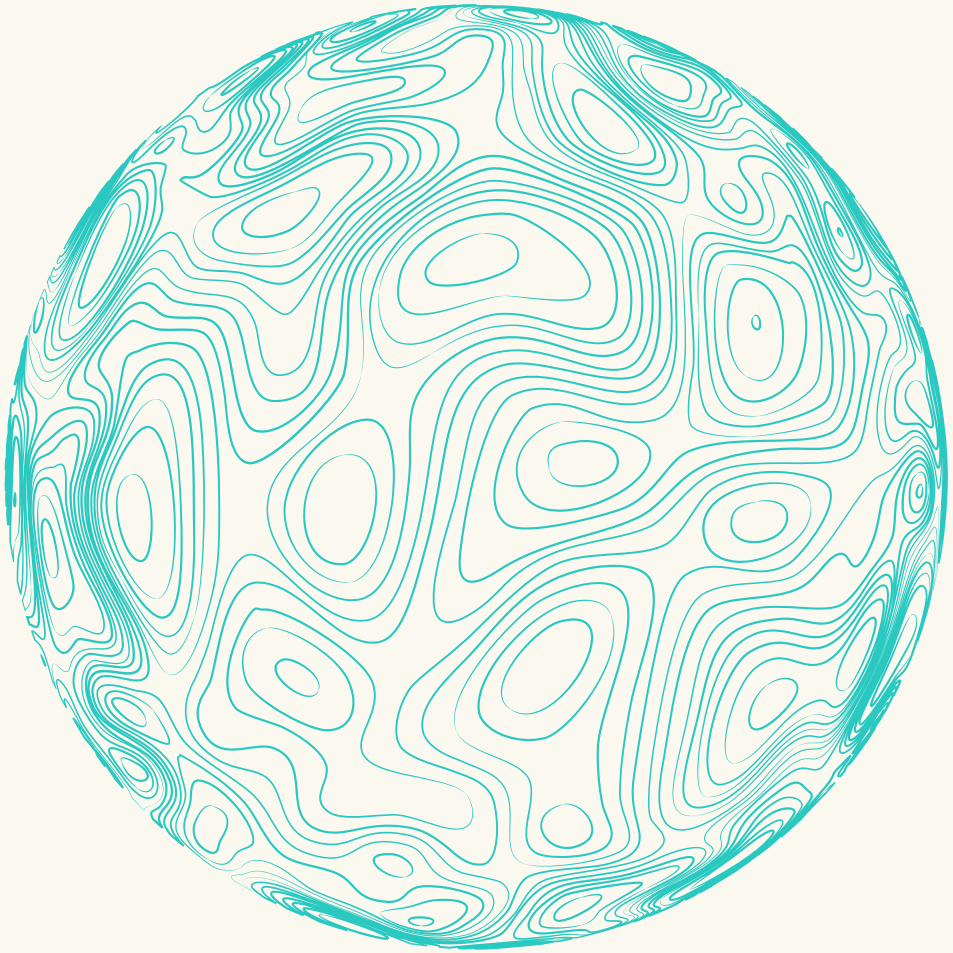
SEAL



What is SEAL?

TECHNICAL INTEGRITY

SAFETY IN DESIGN

SUSTAINABLE DESIGN

SEAL (Safe and Sustainable Engineering for Asset Lifecycle) is the Worley enhanced engineering delivery framework to improve our design from the perspective of technical integrity, safety and sustainability.

SEAL can be applied to any project, for any asset / facility, and at any stage of the asset lifecycle development.

The result is a design for our customers that is:

- Technically compliant with statutory and customer requirements
- Safer to build
- Safer to operate
- Safer to decommission or dispose of, and
- Provide an appropriate sustainable solution

SEAL delivers enhanced outcomes in safety and sustainability for the full asset lifecycle

Worley Sustainable Solutions program has **2,000+ ideas** approved with CO_2 reduction of **450+ Million Tonnes** (as of June 2024)

40,000+ instances of people taking a SEAL training module in the last 3 years

16 New Water Injection Wellhead Platforms powered by photovoltaic solar systems from Saudi Arabia SEAL Case Study

Safety in Design

Work at Heights

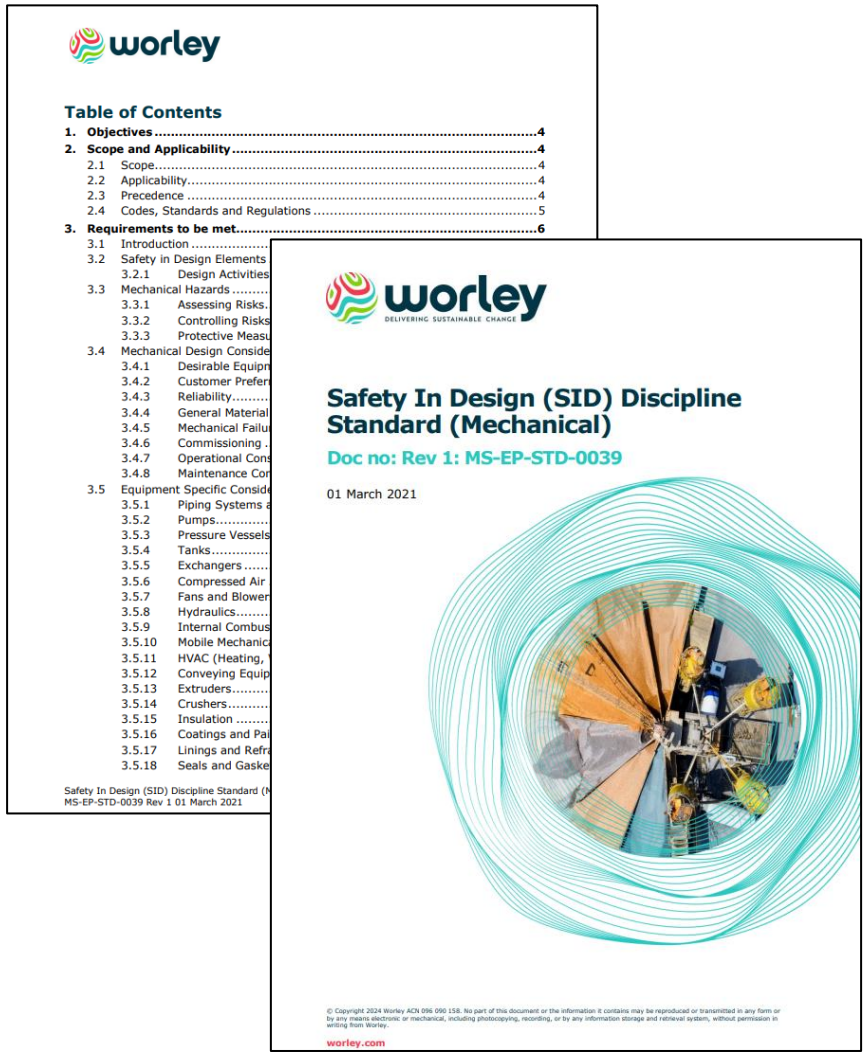
SEAL has 5 principles

Asset Life Cycle	Hazard Management	Persons in Control	Safety in Design (SID)	Sustainable Design (SD)
Our designs consider the Asset Life Cycle	Manage Hazards as part of the design process	People assigned with discrete responsibilities	We apply SID practices to enhance safety	Our process focuses on sustainability

Safety in Design

SEAL delivers safer outcomes by:

- Applying best practices that are documented in Worley's Discipline Safety in Design Standards
- Conducting safety studies and design reviews (eg HAZOP, 3D model reviews) in compliance with our Design Review Standard
- Involving our Safety Engineering Specialists
- Leveraging Customer and Industry requirements



Working at Heights – Basic Layout Considerations

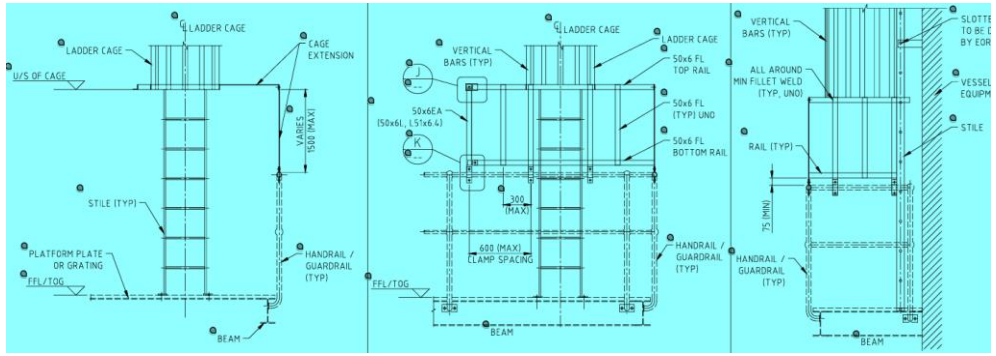
(References- MS-EP-STD-0040, MS-EP-STD-0043)

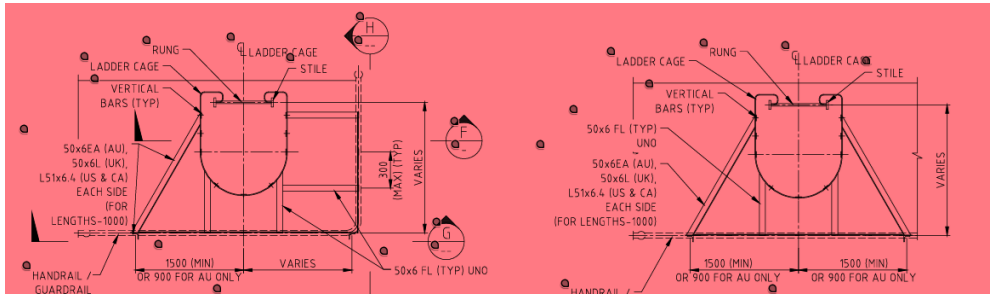
- Walkways on elevated work platforms for vessels/ columns/ towers shall provide **a minimum of 1000 mm clear access between any object and the guardrail**. Additional space shall be provided when operating or maintenance needs dictate

- **Overhead clearance** from the floor shall be maintained: preferred- 2200 mm, and minimum- 2100 mm. Minimum overhead clearance over stair treads shall be maintained as 2100 mm plus the height of 1 riser

- Minimum primary **escape route width** 1200 mm, minimum secondary route width 1000 mm, minimum tertiary route width 800 mm, minimum primary escape route **headroom** 2300 mm, minimum secondary and tertiary routes headroom 2100 mm, **maximum depth** of any passage dead end 5000 mm, **maximum length** of any platform without secondary access 5000 mm

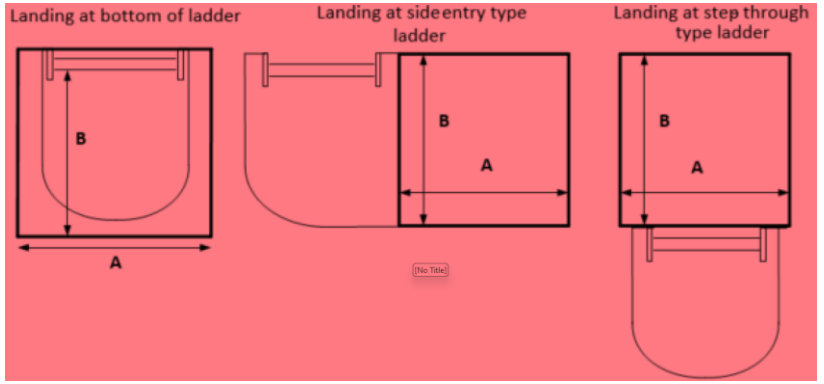
- **Maximum length** of single cage ladder 6000 mm, maximum length of single ladder without cage 2100 mm, minimum distance between **adjacent ladder** centerlines 850 mm, minimum **standing distance** at base of ladder 1200 mm, minimum standing distance adjacent to base of ladder 900 mm

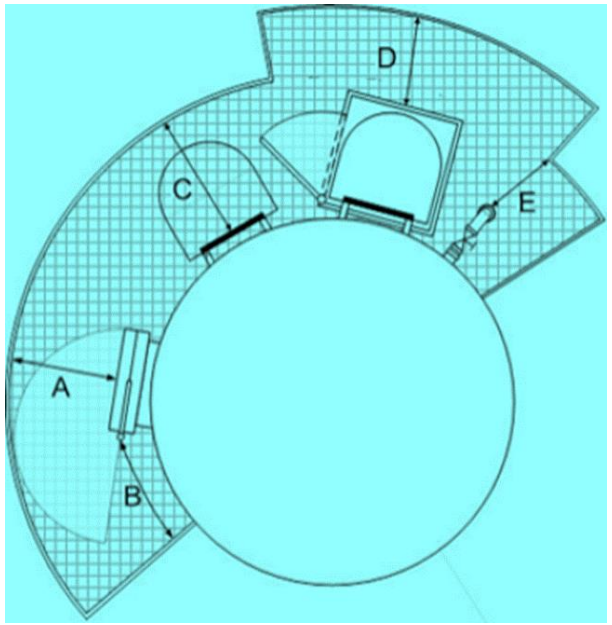




Working at Heights – Basic Layout Considerations (contd.)

- Stairways, rather than ladders, should be provided for main access to elevated structures. Ladders should be reserved for isolated points which are visited infrequently (MS-EP-STD-0040)
- Landing platforms used to access a vertical ladder shall be no less than the following A= 650 mm, B=750 mm, see figure at the right.
- Ladders and platforms shall be provided as required for access to man-ways, operating valves, and instruments. Ladders should be side-step off rather than through.(MS-EP-STD-0040)





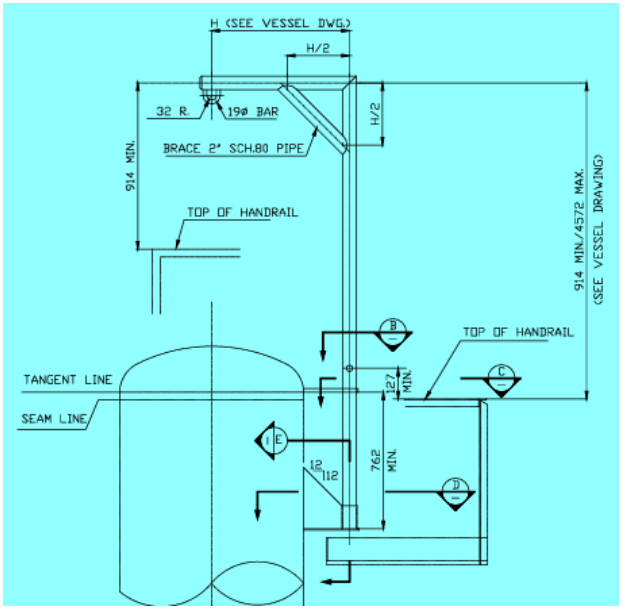
- The standing surface of the platform shall not be more than 1200 mm below the center of manways. Refer figure in the left with following access clearances:
  - **A** (minimum clearance in front of manway) = 1200 mm
  - **B** (minimum clearance on manway cover swing side) = 750 mm
  - **C** (minimum clearance in front of ladder) = 800 mm
  - **D** (minimum access width for walkway on elevated work platform) = 700 mm
  - **E** (minimum access width for walkway on elevated work platform) = 700 mm

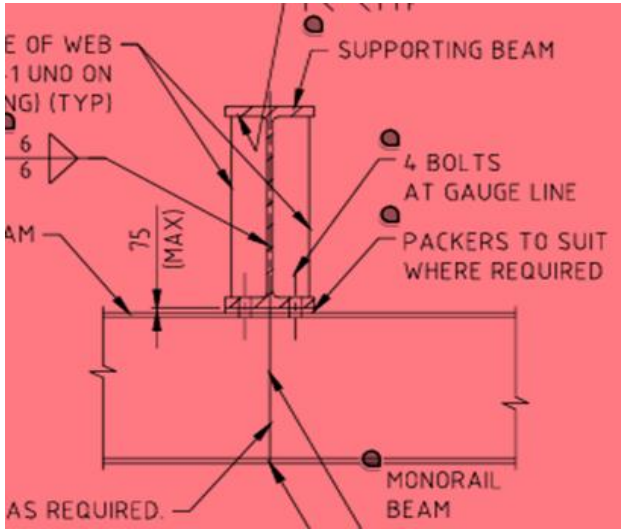
Working at Heights – Basic Layout Considerations (contd.)

- The **maximum human lifting loads** are as follows
  - One (1) person: 20 kg with proper consideration for ergonomically proper lifting
  - Two (2) persons: 40 kg with proper consideration for ergonomically proper lifting

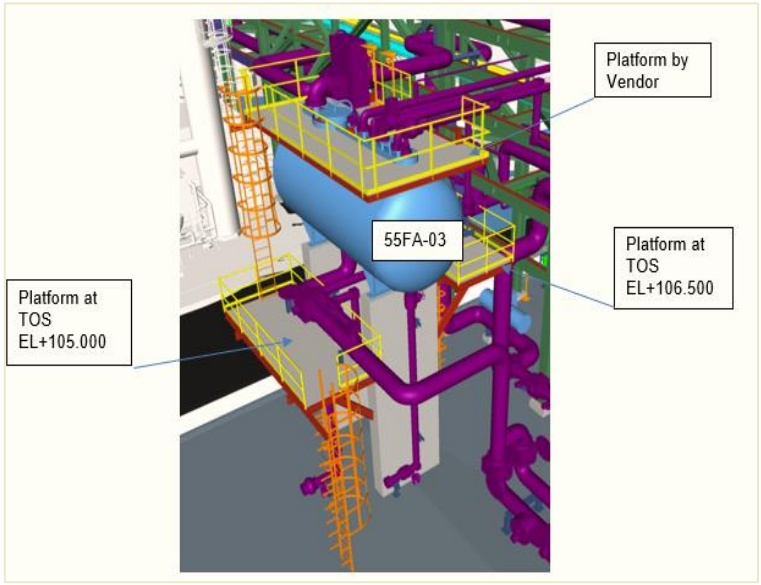
- Design for maintenance, including the need for **fall protection features** when working at heights above 1830 mm or over water or hazardous equipment at any elevation considering design for removal, transfer, laydown and offloading

- **Mechanical lifting devices** include but are not limited to the following:
  - Davit or jib, no hoist only with HSE approval
  - Davit or jib, with hoist only with HSE approval
  - Hoist and beam clamp, depending on clamp, hoist and structural steel capacity
  - Monorail
  - Pedestal crane, Bridge crane, or Mobile crane





Design Examples – Layout Considerations



Worley design considerations

- Ladders located ensuring obstruction-free for easy access and exit to Tank top for operation and maintenance.
- Top platform height is more than 6000mm requiring an intermediate platform to be provided. It also serves the purpose of operation at this intermediate level.
- Preferred side entry Ladders used with safety cage protection.
- Ladder height is more than 2100mm and safety cage is provided.
- Landing points are free from obstruction.

Proactive identification of Safe Escape Routes

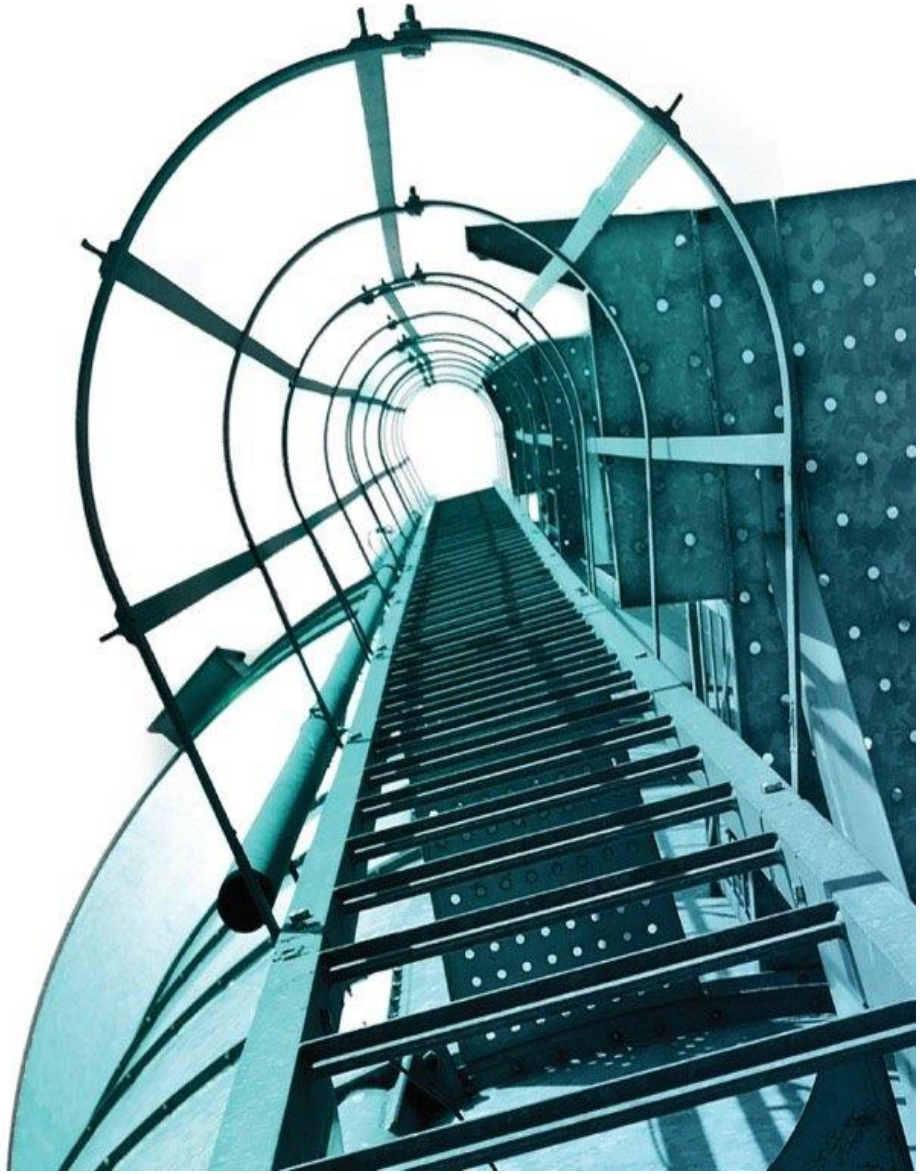
Challenges with congestion and plant layout:

- Proactive approach in establishing escape routes done by layering safe escape routes in the 3D model to ensure they are not obstructed by newly placed equipment and piping.
- Multi-disciplinary 3D model review with customer operations team to ensure all considerations have been captured.

Enhanced Outcomes

- Plant layout has included escape routes for personnel to evacuate the plant safely.
- Early and proactive identification of safe evacuation routes (including from workplaces at height) minimizes change to the project design and hazards.
- Engagement of other disciplines and customers ensure the layout has considered wide stake holder requirements.

SID Mechanical Considerations for Working at Heights



Perform Design based on Safety in design (SID) requirements as per Customer and Worley SID Standards and implement the same during construction/installation of the equipment.

SID standard covers the requirements for equipment such as Platform, Ladders, Walkways, Workspace, and Access to Equipment and Materials, Mechanical Guards, Hot Surface, and Chemical Spray.

Assessment and inclusion of Safety in Design considering Operation and Maintenance aspects :

- Include SID standards in Technical Requisition of the equipment and ensure vendor/subcontractor to follow the same to meet the project requirements.
- Provide Mechanical input related to safety where required to constructability review, 3D Model review, layout review, e-HAZOP, human factors, P&ID review etc.

As per Worley procedures, prepare Discipline SEAL statement (DSS). The intent of the DSS is to

- Promote hazard awareness and provide confirmation that the project/discipline is addressing SID and SD accordingly.
- Provide the discipline with a summary and pointer to areas requiring design focus and hazard treatment/opportunity realization.
- Complements the Project HAZID and Risk processes.

SID for Working-at-Heights Scenarios

Design and provide adequate number of lifting lugs for equipment or component which are to be installed at site, considering minimal scaffoldings and WAH scenarios during installation.

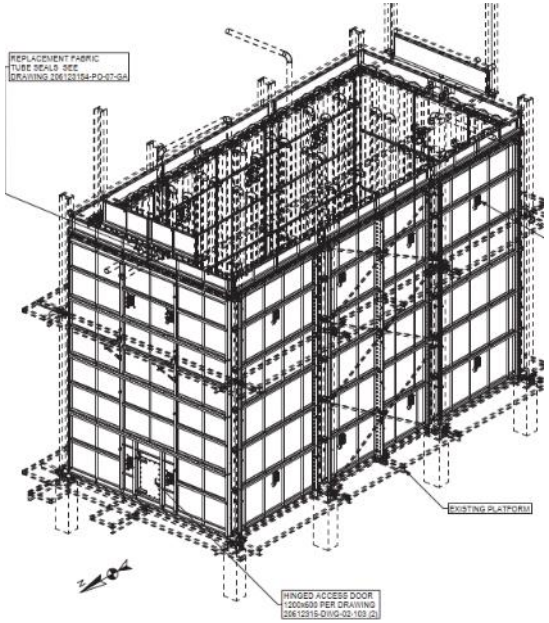
Provide special temporary platforms with handrails where required for performing any modification work (installing internals, welding new nozzle etc.) on existing equipment.

Design and install ladders (with continuous hoops for ladders at elevated platforms, ladder height not be more than 9m, provide required platform widths, guard rails, toe plates, tripping hazard requirements etc. for operating and landing platforms etc.) on equipment strictly as per Safety requirements as per client standards.

Case 1 - Replacement of existing Fired Heater radiant section panels with new panels and new refractory material.

Challenges

- 15m height equipment
- In-situ replacement of heavy panels
- Frequent access required for retrofit activities
- Congested site location
- Adjacent piping, equipment and platforms



Enhanced Outcome

- Optimized the fabrication and construction steps using a modular approach
- Reduced potential rework (involving work at heights) by identifying dimensional discrepancies in early design via laser scan and 3D model reviews

Performed scan of equipment to know the actual dimensions of the equipment, platforms and attachment details etc.

Developed 3D model to determine location of temporary supports for platforms are required during installation of the panels.

Heater radiant panels were designed in modular concept to meet the space and lifting constraints surrounding the equipment.

Designed the panels with required sizes and lifting lugs suitable to site conditions meeting safe handling requirements.

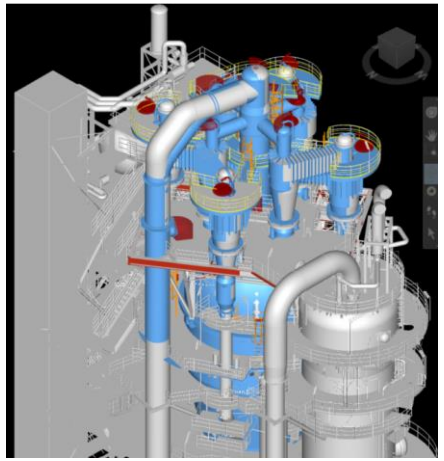
Existing platforms attached to the heater were removed to install new panels.

Designed temporary support members welded to main heater existing structural members for installing temporary platforms and scaffoldings based on panel sizes and space constraint for erection and installation of the panels. Reinstalled the existing platforms after installing the panels.

Case 2 - Replacement of Cyclones on Existing Reactor

Challenges

- Installation of heavy / bulky equipment components at height (~30m)
- In-situ replacement of cyclones and central plenum
- Frequent access required for retrofit activities
- Congested site location
- Adjacent piping and platforms



Enhanced Outcomes

- Optimized the fabrication and construction steps using shop trial fit and site pre-assembly
- Reduced work at heights by including jigs and guides at grade level during site pre-assembly
- Reduced potential rework (involving work at heights) in early design via laser scan and 3D model reviews for ensuring proper alignment with the existing equipment

Project Scope: One to one Replacement of the cyclone system of an existing reactor. Based on the Safety reviews and FEED phase study, additional platform included on the upper plenum of the Cyclone system for access during operations. This requirement has been included in the Vendor Requisition and the same has been implemented during the detailed phase as per the operation/maintenance requirement and SID requirements of the Customer (avoiding temporary scaffolding during maintenance and hence addressing safety).

There were studies conducted during the FEED Phase on the trial fit of the Cyclone assembly at fabrication shop and at site installation. During the design phase, the strategy for **shop trial fit, site pre-assembly and actual site installation** was finalized. Alignment guides and jigs were designed, engineered, and fabricated to link up primary cyclones with inlet ducts, link up secondary cyclones with plenum and outlet of primary cyclones.

CHRIS ASHTON
Chief Executive Officer

The safety and wellbeing of ourselves and those around us is fundamental to Life. Without this, nothing we do is worth doing.

Q&A

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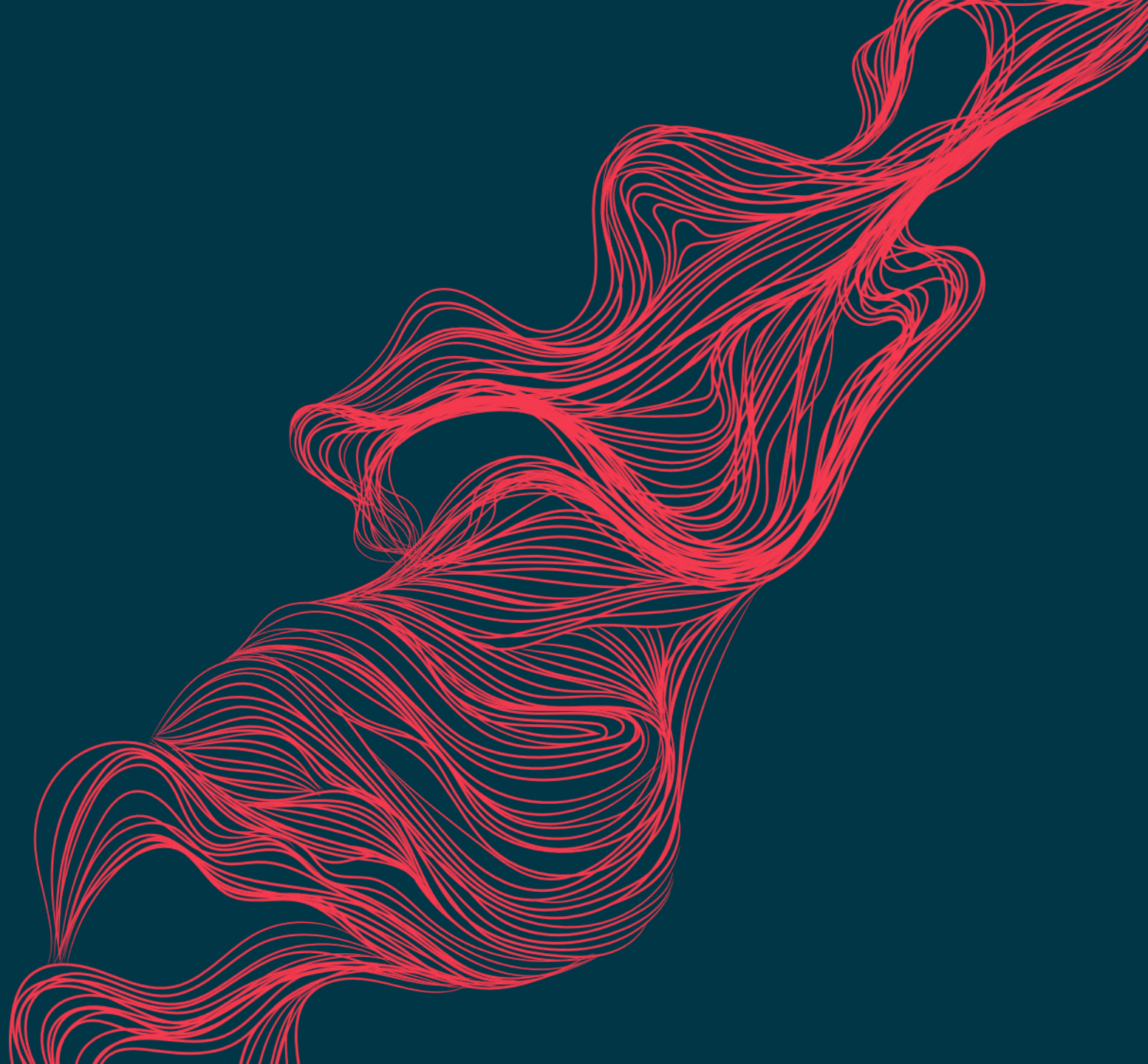


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