COAA
Construction Owners
Association of Alberta

MODULE ASSEMBLY FRAMEWORK

A Best Practice Tool of the Construction Owners Association of Alberta

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EXECUTIVE SUMMARY

This module assembly framework has been developed as a guideline to assist all module stakeholders in developing their own project-specific module assembly plan. Rather than create a document that attempts to address all possible considerations through a module project lifecycle, this best practice tool is based on using "principles" as a means of conveying best practices for each module assembly element. See Appendix A for a detailed description of what a principle is as it relates to this best practice tool. This principle-based document, which is high level in nature, should be interpreted and implemented by an experienced module management team.

Establishing a module management team at the front end of the project is considered essential to define the parameters of the module assembly plan for the project. This team could be one person or many depending on the size, complexity, and specific requirements of the project. The team should be comprised of individuals with subject matter expertise in all 10 elements of the best practice tool. As a minimum, the team leader should progress with the project to support the modularization program through the design and construction stages of the project.

This best practice tool builds on previous lessons learned in the module industry gathered from industry professionals. Many elements of this document are interdependent: readers should use it in its entirety and be cognizant that one section may impact another.

As stated above, this document is a guideline that can be used in developing a module assembly strategy and execution plan specific to your project needs and requirements. An overall higher level modularization strategy should be developed that considers location, access, and project specific requirements prior to the development of the module execution plan. Once the execution plan is developed, following a rigorous change management process will reduce overall project impacts.

This document supports the COAA initiative of TWICE AS SAFE, TWICE AS PRODUCTIVE BY 2020. Users of this document should consider referencing other related COAA Best Practice documents which are easily accessed on the COAA website http://www.coaa.ab.ca. This tool does not address safety as a specific element but rather relies on the already established safety best practices developed and adopted by COAA members.

***PREFACE*: WHAT AND WHEN TO MODULARIZE**

The decision to modularize is better described as the opportunity to modularize. There are many reasons to consider modularization on your next project, but there are also situations where modularization may not add the intended benefit. There is no one size fits all solution for modularization. The most common benefits of modularization are:

- Improved project schedules by performing fabrication and module assembly in parallel with site development and piling program
- Improved quality due to a controlled module yard environment and repetitive work
- Reduced site execution risk by transferring substantial labour hours to module assembly yards lowering peak direct labour and supervision requirements
- Reduced indirect labour costs at site including scaffolding, hoarding, temporary facilities and burdens associated with remote locations where camp and travel costs are high
- Improved skilled labour availability in major centers where module assembly yards are located
- Improved safety performance in the controlled module yard environment and reduced working heights
- Improved productivity in module yards due to facility layout and permanent fixtures, lighting, electrical, cranes, lunchroom proximity, warehousing and material handling (more tool time)
- Opportunity for higher worker to supervisor ratios in module yards
- Opportunity for testing and pre-commissioning activities to be performed offsite resulting in improved turn over to operations
- Reduced site laydown space requirements over stick built construction

Despite the aforementioned benefits of modularization, when compared to traditional stick-built construction, there are additional complexities which need to be considered.

- Modularization adds to design complexity. Provide allowances for connections between modules, additional steel (up to 15-20%) for transportation loads and bracing, breaking expansion loops that exceed shipping envelopes and ensuring all pipe is supported on steel in each module envelope
- Increased complexity in materials management. Ensure the correct materials in bulk orders are allocated to fab shops, module assembly yards and site. Examples are pipe shoes and welded valves to the fabrication shop, bolted valves and pipe hangars to the module yards and final bolt up materials to the site. These determinations need to be made early and managed properly
- Modularization often requires early release of steel and pipe fabrication drawings; therefore, the incidence of revisions to the designs are higher and may result in increased cost
- Logistics studies are required for the transportation routes from the module assembly yards to the site to determine maximum shipping envelope dimensions and weights. This could include bridge studies and overhead wire surveys early in the project development. Depending on the distance between the assembly yard and site, multiple jurisdictions may be involved
- Long lead items such as control valves, instruments and special metallurgy may require the fabrication of dummy spools in place of the item to allow piping installation to proceed in the modules, the result of which can be incorrect final dimensions or late design changes
- Increased density of the modules can obstruct access to equipment or hamper future maintenance activities

- Increased size and weight of modules could result in increased crane and ground preparation costs including heavy haul access roads, larger turning radii for roads and higher compaction requirements

What types of projects or components typically benefit from modularization?

- Processing plants for oil and gas, petrochemical, fertilizer or other facilities with dense processing units that would result in substantial manpower requirements working at multiple elevations simultaneously
- Installations that are more than 150 km from a major fabrication center or would attract travel and accommodation costs to obtain the required number of skilled tradespersons
- Regions with chronic labour shortages, unfavorable labour market conditions or lack of qualified contractor selection
- Regions subject to harsh environmental conditions (extreme temperatures, excessive rainfall or high wind conditions) that would adversely affect site labour productivity
- Projects that have good access to high load corridors and heavy haul routes with known limitations
- Plant components particularly well suited for modularization include;
    - Dense pipe racks and process areas
    - Electrical buildings, MCC's, remote instrument building's and pump houses in 24' wide sections
    - Stair towers and structural assemblies containing lighting, cable tray or building cladding
    - Gas processing skids, well pad control skids, fired heater sections, HVAC skids
    - Retrofit or additions to existing operating facilities (brownfield) where permitting or hazardous environments reduce labour productivity
    - Commodities that allow for bolted joints at module terminations

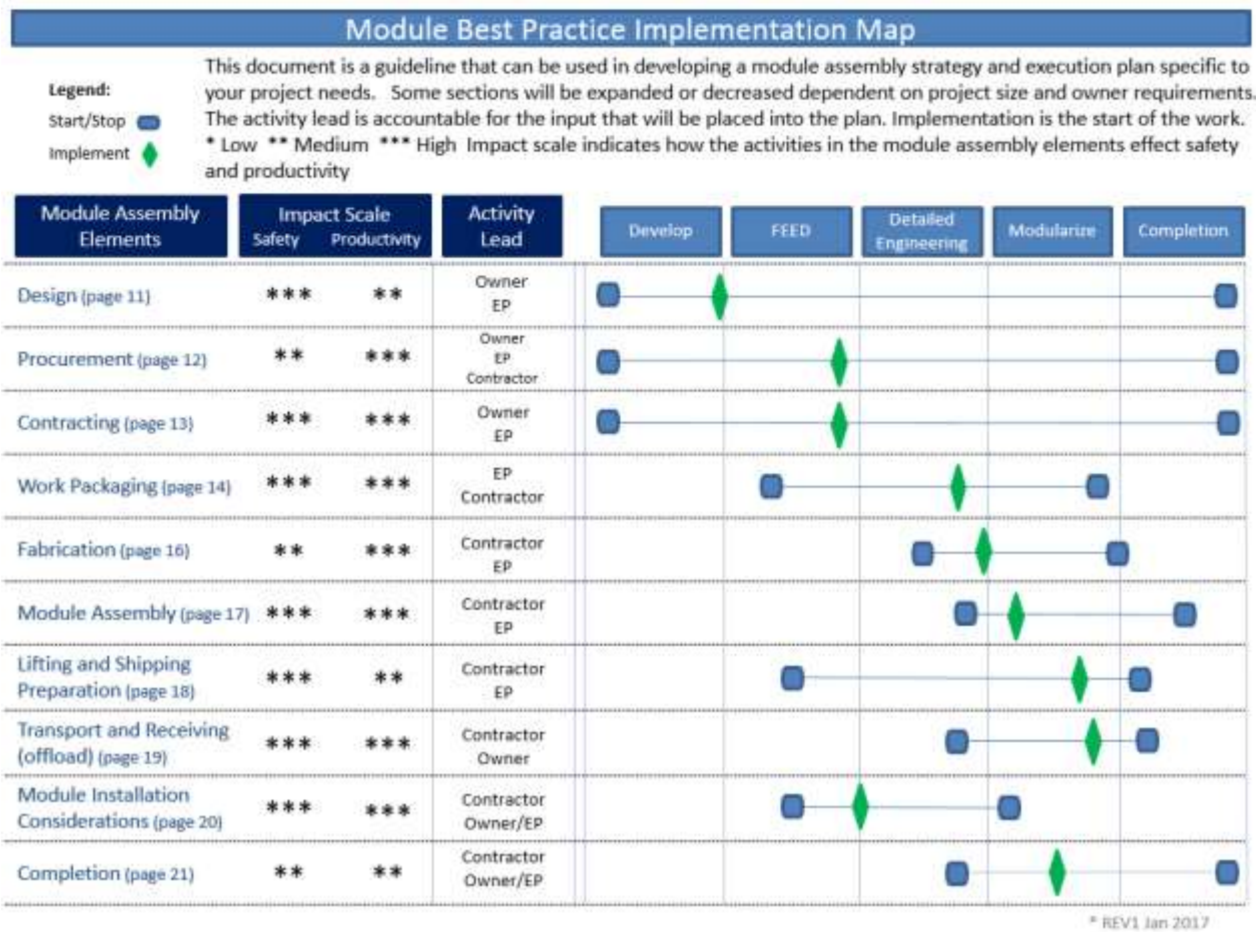
What types of projects or components typically do not benefit from modularization?

- Single tier pipe racks (sleepers) and cable trays or sparsely populated pipe racks as the labour component saved over stick built construction will not offset the module freight costs
- Large pumps or other rotating equipment that require substantial bases or controlled alignment
- Designs that would require and inordinate amount of temporary shipping bracing
- Large vessels, exchangers or equipment that consume the volume or weight limitations without significant labour requirements for piping, controls and electrical
- Unproven technology or fast track execution where considerable revisions are anticipated or all discipline engineering will not support the modularization schedule. Examples would be late piping stress analysis, complex instrumentation or heat tracing design that will not support the schedule. Designs with long lead welded in components such as high pressure valves or flow devices that will not support the module schedule
- Plant locations that have geographic or space constraints that will not facilitate delivery of modules to the setting location

There is opportunity for significant safety, cost and schedule benefits through the successful implementation of modular construction but the analysis of the total installed costs needs to take place prior to implementation. Once a preliminary commodity quantity is determined and field labour and overheads costs have been estimated, a cost benefit analysis can be undertaken to determine the full benefit of modularization. Basic information that will assist in a preliminary benefit analysis includes:

- Fully burdened site labour rate including scaffold, camp and travel costs if applicable
- Anticipated rates of placement (productivity factor) for site work
- Shop fabrication and module assembly yard fully burdened rates and productivity factor
- Estimated cost per load for module transport to site
- Crane sizing and estimated cost
- Allowance for increased steel, temporary supports and securement required for module transportation
- Confirmation that the engineering and procurement schedule can support early release of fabrication and module assembly work packages

MODULE BEST PRACTICE IMPLEMENTATION MAP



MODULE ASSEMBLY ELEMENTS

1.0 DESIGN

A key component to the success of a module program is early planning (i.e. development of a module execution plan and design philosophy), including consideration of modularization during plot plan and early design development. Without early planning, projects run the risk of developing designs that do not maximize the benefits of modularization. Therefore, a key element in the design section of this document is the focus on completion of the activities listed below in the pre-detailed engineering phase of a project. Also, a key to success is the involvement of the right parties in planning a modularization program, which is emphasized in this section of the document.

This section of the module assembly best practice is intended to identify key considerations to be evaluated by projects in deciding what to modularize. In addition, it also outlines design constraints that need to be defined and clearly communicated to the design team to ensure the effective implementation of a module program.

It should be recognized that this best practice includes guidance that influences module design. Therefore, the development of design concepts and limitations must consider all sections of this best practice.

1.1 Complete a module execution plan during FEED

- Establish a complete module management team and include the team in the front end discussions to bridge the gap between design and construction
- Develop an execution plan, based on the project modularization strategy, prior to DE

1.2 Preparation of a module design philosophy/framework early in FEED

- Prepare and complete the module design philosophy prior to detailed engineering, in order to eliminate issues throughout the project. (e.g., standardization, repeatability, optimization, etc.)
- Create engineering guidelines in consideration of this entire module assembly framework, as well as the following:
    - Early understanding of shipping envelope and weight restrictions
    - Well defined MIWP/EWP packing relationship early in FEED
    - Integrated design specifications and standards
    - Alignment considering all different interfaces (i.e., transportation, installation, codes & standards, pre-commissioning, etc.)
    - Decide what components are included in the modules (i.e., instrumentation, pumps, cladding, stick built, etc.)
    - Define the orientation of the module, establish datum and ensure it's on each module's GA
    - Consider bolted connections for construction of both pipe and steel
    - Consider designing construction or transportation support steel as permanent where practical

- Consider designing permanent and/or temporary access to work fronts that can be leveraged in the module yard as well as at site

1.3 Modularization should be a primary driver for development of the plot plan layout early in FEED

- Develop module index during FEED
- Develop module key plan during FEED

1.4 Constructability involvement starting early in FEED then DE

- Module installation methodology clearly established (i.e., SPMT setting, crane, supermodules, etc.)
- Installation sequence or path of construction needs to be established

1.5 Minimize all changes

- Freeze the design once it's issued

2.0 PROCUREMENT

The intent of incorporating a Procurement Plan is to ensure that with up-front, early and accurate planning any last minute changes can be avoided. Most potential savings can be achieved through effective procurement planning by identifying the lines of responsibility for the supply chain/ expectation of stakeholders. Proactive measures can be taken to ensure contingency planning to mitigate any potential risks which may arise throughout the procurement process, regardless of project scale.

2.1 Develop and share a procurement plan with all applicable stakeholders

- Plan should consider the project through its entirety but specifically support module assembly
- Plan should be developed at project start with engagement by the key stakeholders

2.2 Procurement plan should include:

- Fit for purpose design module specifications
- Complete bill of materials
    - Destination: fabricator, assembler or site
    - Design: approved manufactures list, client's supplier of choice, commodity codes
    - BOM: bill of materials per module
- Materials supply responsibility matrix
- Long lead items
    - Early identification is critical
    - Availability of materials may impact scheduling decisions
    - Consider modifying downstream activity (e.g., installation of dummy spools, spacers, etc.)
- Management of material substitutions
    - Ensure the construction drawings accurately reflect the materials being substituted
- Material management plan should include:

- Laydown space requirements
- Sequencing and priority of material
- Storage and preservation
- Warehousing requirements
- Staging requirements

- Receiving plan for OS&D's
  - Review design specs
  - Equipment plan with receiving materials
- Logistics plan
  - Consider and define the logistics strategy (e.g., push vs pull)
  - Determine the receiving capacity at the destination and schedule accordingly
  - Make a cross border materials plan for out-of-country equipment and materials to ensure continuous and on time delivery

3.0 CONTRACTING

Contracting is a key activity for all module execution programs. Key elements for contracting would include development of a contracting strategy, identifying cycle timelines for contracting processes, planning for close-out activities and management of executed contracts. Early planning and development of project contract strategy and processes will provide the project team with strong guidance on issuing of contracts and minimization of the risk to the project with effective contracts and contract management.

3.1 Define sufficient time for entire cycle of contract process

- Bid, qualifications assessment, selection, negotiation and award
- More detailed planning and engineering on the front end will improve bid cycle time and accuracy

3.2 Develop a contracting strategy including:

- Prequalification
- Expression of interest
- Type of contract (matched to terms)
- Early transmittal of terms and conditions to reduce cycle time
- Understanding reporting requirements
- Consider the use of MSA's (suppliers of choice)
- Identify which commodities are being tendered
- Meeting schedule including kick-off
- Communication to subcontractors
- Change management
- Quality requirements
- Turnover
- Invoicing procedures and payment
- Insurance and warranty provisions
- Office space requirements including IT and parking

3.3 Provide a well-defined scope of work including:

- Complete set of IFC drawings
- Schedule and module sequence
- Specifications and guidelines

3.4 Prepare a close-out plan including but not limited to:

- Notice of completions (substantial and final)
- Statutory declarations
- Lien waivers
- Claim resolution
- Warranty transfers back to client
- Client close-out activity (e.g., surplus materials, equipment, office space, etc.)
- Audit requirements
- Lessons learned

3.5 Manage performance compliance

- Establish and define project performance indicators:
    - Invoicing
    - Payment
    - Manpower (i.e., scorecards)
    - Schedule
    - Cost
    - HSE performance
    - Inspections (i.e., safety and quality)
    - NCR's
    - RFI's
    - Material management

4.0 WORK PACKAGING

The purpose of this section is to provide the module management team with recommended elements to consider in the development of complete and consistent work packages. The expected results of a good work packaging program would increase productivity and control, which translates into lower costs.

4.1 Conduct work package scope review

- Kick off meeting with appropriate stakeholders to review all work package elements

4.2 Work package sequencing

- Generate the work packages by module, by discipline and released progressively in accordance with the module construction sequence

4.3 Develop work package elements considering:

- Scope of work
    - Include a model shot of the module (a picture is worth a thousand words). In order to quickly reference the intended scope
    - Summary description of the scope of work
    - Work included, by discipline (clearly define any ship loose components)
    - Work excluded, by discipline

    - Key execution milestones, MIWP IFC date, material availability, required module ready to ship date
- Technical documents
    - List of all EWPs associated with the package (e.g., structural steel, piping, instrumentation, electrical, etc.)
    - List of applicable specs and standards
    - Drawing list by discipline (e.g., module key plans, P&ID's, isometrics, system scoping drawings, module GA's, shop drawings, steel and pipe spool cut sheets, erection drawings, vendor drawings, etc.)
    - Holds list (complete listing of holds associated with this package and expected dates of release)
    - Temporary material requirements (e.g., dummy spools for valves, PSV's if required, etc.)
    - Shipping drawings, detailing COG, temporary supports and beams if required, loading configuration, etc.
    - Lift study (recommend including special requirements for lifting - capacity of cranes and spreader bars required)
- Materials
    - Material responsibility matrix (owner, EP, vendor, contractor, fabricator)
    - Provide BOM, by module to cover all disciplines, tags, equipment, bulks, free issue, shoes and pipe supports. BOM should be provided in an Electronic sortable format, including ETA dates and destination (fab shop, module assembly yard, site)
- HSE
    - Identify any safety considerations or precautions. (e.g., equipment sent with N2 purge or energized battery)
- Quality
    - Code of construction
    - Inspection and test plan
    - Special preservation requirements
    - Regulatory or permit requirements, provide ABSA PP # if applicable, identify any permit requirements (e.g., CSA inspection, architectural inspections, etc.)
- Specialty subcontractors
    - Specify any required specialty contractors that contractor will be required to use (e.g., high voltage testing or inspection)
- Vendor support
    - Provide a specific list of equipment that will require vendor assistance or special hold point requirements along with the applicable vendor contact information.
- Project controls
    - Integrated schedule
    - Progress and performance measurement (would recommend rules of credit for all disciplines of work for earned progress)
    - Identify summary level quantities by discipline
        - Steel, light, medium and heavy

        - Pipe length by diameter
        - Quantity of tags and equipment
        - Length of cable tray and cable
        - EHT quantity and length
        - Insulation quantity and size (consider including this by type and thickness)
- Risk register
- WorkFace planning – include a detailed list of associated IWPs included with this work package with their scheduled release dates
- Turnover
    - System definition
    - Tag cross reference list
- List of pre-commissioning activities applicable to module scope

4.4 Scope repetition when possible

4.5 Minimize all changes

- Don't release the work packages until the design is complete

5.0 FABRICATION

The purpose of this section is to ensure delivery of fabricated materials in an organized manner to support effective module assembly and to ensure completeness of the pre-fabricated packages. The expected result of properly planned fabrication will reduce on-site waste during module construction; therefore, optimizing module assembly.

5.1 Engage fabricator at earliest stage of engineering design

- Understand the scope of services that the fabricator can provide, including weld capacity, shop capacity, space capacity, etc.
- Identify the extent of pre-assembly
- Update the module execution plan as required

5.2 Issue finalized IFC drawings prior to commencement of the fabrication work

- Agree on standard details
- Agree on pre-assembly scope as identified in item 5.1 above
- Standardize design (related to work packages)

5.3 Deliver all required materials to fabricator prior to start of fabrication

- Provide comprehensive bill of material and required documentation
- All pipe shoes and supports to be ordered and available when pipe fabrication starts
- Just in time delivery of fabricator-supplied material
- Confirm availability of all free-issued material prior to fabrication start
- Provide clarity on destination of materials (i.e., clear communication as to what ships to fabricator and what ships to module assembler)

5.4 Avoid design at modular fabrication level by including all required fabrication details (e.g., support for miscellaneous piping, electrical, etc.)

- No field run installations
- Engineering design to include temporary supports
- Bill of material to include all required items
- All installation details to be included with material supply
- Storage and preservation requirements to be included with equipment items

5.5 Maximize fabricated pre-assemblies for construction efficiency

- Consider fabricator for assembly of single discipline components (e.g., stairtower, large assemblies, etc.) to work in tandem with main module assembly yard

6.0 MODULE ASSEMBLY

The purpose of the module assembly strategy should identify, define and incorporate an assembly plan that supports the installation sequence priority. The expected result of a well-defined module strategy should maximize modularization efficiency.

6.1 Ensure stakeholders agree on MIWP content in advance of module assembly

- Refer to item 4.0 work packaging for MIWP content details

6.2 Ensure stakeholders agree on quality management plan in advance of module assembly

6.3 Complete design prior to commencement of module assembly

6.4 Deliver module assembly materials with one module per load where practical

6.5 Seek early module assembly contractor input in the engineering, procurement and construction planning for an integrated project schedule

6.6 Module contractor encouraged to utilize work face planning and/or lean manufacturing principles

6.7 Ensure materials are delivered per forecasted module assembly schedule

6.8 Limit requirements for marshalling and handling

6.9 Ensure the module yard infrastructure supports the project plan

- Consider land, facilities, standing module count, marshalling space, access/egress, transportation logistics, etc.
- Consider module assembly cycle time by module type, density, complexity, etc.
- The module yard should have an optimized module location plan to minimize yard labour, maximize the workface planning, and ensure the delivery sequence

7.0 LIFTING AND SHIPPING PREPARATION

The purpose of this section is to focus on key areas that assist with design optimization strategies that minimize rigging complexities and to ensure the modules can be loaded and permitted as efficiently and effectively as possible. In all modularized construction programs, transportation and lifting forms a key part of the logistics chain in delivering the modules from the off-site assembly yard to the foundations.

7.1 Avoid modules with unequal lift lug elevations

- Consider the impact of additional field hours required to assemble the rigging so the module can be lifted level versus the cost of steel savings
- Consider the cost and time required for a rigging study. A rigging study can save time in the field for non-standard rigging arrangements

7.2 Ensure lifting lugs are sized to fit the required shackle size

- Provide suitable hole size
- Provide suitable distance from hole to top plate to fit slings through
- Consistent design of lug and web plate thicknesses

7.3 Minimize the number of lift points

- Module designers to determine the minimum number of lift points on the columns (e.g., consider the example of a bridge module which is designed to be supported on the ends only but requires additional lift points on the internal bays)
- Standardize module lifting points and module bay spacing to reduce rigging changes

7.4 Centre the centre of gravity

- Large centre of gravity offsets requires non-standard rigging arrangements
- Install lift lugs above the centre of gravity to reduce load stability issues where practical

7.5 Eliminate obstruction of lifting lugs

- Ensure piping and/or cable trays installed in the module do not interfere with rigging

7.6 Eliminate under hanging equipment

- The underside of the lowest beam (e.g., module structure member or shipping beam) must always be the lowest dimension within the footprint of the trailer

7.7 Ensure weight certainty and control

- Implement a module weight control plan to ensure the modules are not above the allowable shipping weight to avoid removing items that are already installed

7.8 Ensure width and height control

- Dimensional checks should be performed in the weeks prior to shipment
- Provide suitable access to perform dimension checks close to the time of shipment
- Understand the limitations from the module assembly yard to the high load corridor
- Include the shipping beam and blocking height in the shipping envelope

7.9 Consider the shipping season when developing the construction schedule

- Allowable load limits are lowest during spring road ban season and are higher at other times of the year

7.10 Ensure module readiness to support RTS date

- Ensure the module is complete prior to mobilization of the transportation contractor

7.11 Consider access and egress in module yard layout

- Consult with the transport provider to plan access and egress of the transportation equipment

7.12 Ensure adequate lashing and tie down provisions

- Ensure there are suitable and sufficient number of tie down points
- Consider fireproofing, insulation, cladding and other obstructions when designing tie down points

8.0 TRANSPORT AND RECEIVING (Offload)

The purpose of this section is to focus on key areas to ensure safe transportation practices over public highways and to encourage the management team to consider the advantages and disadvantages of various module offloading strategies (e.g. push versus pull). In all modularized construction programs, transportation and offloading at site form a key part of the logistics chain in receiving the modules safely at site.

8.1 Be aware of the stability risks of modules with high centres of gravity

8.2 Integrate the transport beam into the module design

- Design the lower level module members with sufficient capacity for transportation, self-loading and offloading

8.3 Consider shipping beams if design does not allow integrated transport beams

- Define the party responsible for supplying the shipping beams
- Ensure shipping beams are available to module assembler prior to assembly

8.4 Consider self-loading trailers vs crane hoisting

- Height from grade to underside of the shipping beam to be built at a suitable height to support self-loading

8.5 Special considerations required for short heavy modules

- Consult transport carrier regarding short heavy modules as they are often not suited for conventional transportation

8.6 Rail transport considerations

- Rail transport considerations are considerably different than highway transport considerations
- Check the limits for dimensional loads (length, width, height, weight) for each rail carrier between the origin and the destination
- Provide a rail transport drawing along with the dimensional load clearance request; an end-view showing various widths at intermediate heights above the rails is particularly important
- Always check the expiration date of the clearance specifications prior to committing to design changes

- Consider centre of gravity and securement requirements. Ballast weight may be required to lower the centre of gravity
- Consider how to load and transport from the fabricator to the rail siding at the origin Consider how to transload and transport from the rail siding to the destination at the project site

8.7 Consider off-loading strategy when preparing modules for transport

- Straight to hook/just-in-time offloading
- On-site laydown/staging offloading
- Direct to piles/self-offloading
- The module orientation (cab end) must be considered, especially if the module is going straight to hook or direct to pile

9.0 MODULE INSTALLATION CONSIDERATIONS

The purpose of the section is to provide the module management team with module design considerations in an effort to make installation safer and more productive. The installation of modules on site requires a comprehensive execution plan. The development of the plan needs to start early in the engineering phase as many of the early design decisions can have a direct effect on the installation program. Subject matter experts should be utilized to review the installation considerations listed below and to make recommendations.

9.1 Reduce work at heights prior to module setting (where possible)

- Do everything possible to reduce work at heights by performing as much work on the ground as reasonably practical
- Ensure lifting lugs are integrated into columns; avoid bolt-on lugs. This should be considered during the design phase
- Ensure identification and correction of all missing components, shipping damage, shipped loose and deficiency items
- Preinstall accessibility measures to improve access at heights (e.g., scaffold or lifelines)
- Identify and remove as many of the temporary lashings, supports and tie downs as reasonably practical

9.2 Ensure early involvement of module installer

- Involve constructability personnel early in the design phase
- Develop an execution plan for on-site module installation. The installation plan should include delivery and site setting sequence, path of construction and selected methods for site installation (i.e., self-propelled module transport, direct to hook, jack and roll, etc.) Understanding and involvement of relevant stakeholders during the early project phases is critical
- Minimize the amount of testing to be performed on site by maximizing the testing in the shop and yard
- Reduce the amount of pneumatic testing on site to reduce the exclusion zone

9.3 Consider bolted construction of interconnects

- Improve efficiency by using bolted structural steel connections
- Where practical, use bolted versus welded piping connections

9.4 Consider preassembly at site

- Consider a laydown area to assemble super modules (joining several smaller modules together) then move the super modules into place with self-propelled modular transporters (SPMTs)
- If practical, ship loose material for each module should be shipped with the module for ease of installation

9.5 Plan for site conditions

- When developing the overall site layout plan, ensure the size of the roadways are wide enough to accommodate the module transportation and cranes that will be used
- When using a site laydown, ensure the laydown area is close to the setting area and is of adequate size

10.0 COMPLETION

The intent of this section is to provide the elements required to ensure successful completion of the module program. Starting with the end in mind will condition the project engineering team to provide the deliverables required for a successful completions and commissioning strategy. The intent is to identify the requirements and the stakeholders responsible for those requirements.

10.1 Define pre-commissioning/commissioning requirements

- Clearly define your pre-commissioning/commissioning strategy and who is responsible for the commissioning during front end planning so that it can be included in the Module Work Package (MWP)
    - Pre-commissioning/commissioning activities could include the following; hydrotesting, line flushing, special line cleaning requirements, point to point checks, loop testing and in some cases equipment run-ins
- Create a pre-commissioning/commissioning work package or a testing and commissioning activities matrix outlining what is included in the module yard scope to avoid gaps or duplication (e.g. hydrotesting)

10.2 Define turnover requirements

- Define project specific module turnover process and deliverables
    - This should be defined early and included in the module assembly contract. Include payment hold backs to ensure turnover deliverables are completed in a defined time period
- To expedite delivery of modules to the work site, it is a best practice to determine what turnover documentation is required with delivery of the module
    - Typical turnover documentation shipped with the module would include AB83 or AB83F, marked up red-line drawings showing any modifications completed at the module assembly facility, module deficiency list and load packing slip and signed off module release form

10.3 Identify all temporary materials that must be removed at site

- Consider prepackaged materials (e.g., insulation block outs, interconnects and bolt-up)

- Clear identification for items requiring removal to be provided with markup drawing, painting or other identifiers
    - Methods of identification could include clearly visible paint such as florescent orange or green, marked up drawings or mapping to show temporary materials, inclusion of module ship loose, or deficiency list

10.4 Remediation of deficiencies and scope transfer

- Clear identification for items requiring removal to be provided with markup drawing, painting or other identifier
- Ship a copy of the deficiency list and supporting documentation with the module
    - All attempts should be made to complete all deficiencies at the module assembly facility. If for any reason a decision is made to ship the module with any deficiencies, these need to be clearly defined on a shipping deficiency list and included both with the module shipping documentation as well as the turnover documentation
    - All attendees of the module final walkdown should sign-off on the deficiency list generated
- Use or establish a process to transfer any uncompleted scope from module yard to site contractor
    - Process is required to identify any module yard scope that could not be completed and formally transfer this scope to site. This is required so that site contractor is aware of additional scope and can price it into their work. Examples of scope transfer may be uncompleted insulation due to shipping braces, material not installed because it could not be provided to module yard in time, etc.

APPENDIX A: DEFINITIONS AND ACRONYMS

Definitions

Datum: Point of reference on the module common to all drawings by all contractors

FEED: For the purpose of this document, any activity prior to detailed engineering.

Principle: "A fundamental truth; a comprehensive law or doctrine, from which others are derived, or on which others are founded; a governing law of conduct" – Definitions.net

Super modules: joining several smaller modules together to form a larger module

Acronyms

ABSA	Alberta boiler safety association
ABSA PP#	ABSA pressure piping registration number
BOM	Bill of material
CG/COG	Centre of gravity
CSA	Canadian Standards Association
DE	Design engineering
EHT	Electrical heat trace
EP	Engineering and procurement contractor
ETA	Estimated time of arrival
EWP	Engineering work package
FEED	Front end engineering design
GA	General arrangement drawing
HSE	Health, safety, environment
IFC	Issued for construction
MIWP	Module installation work package
MSA	Master services agreement
NCR	Non-conformance report
N2	Nitrogen
OS&D	Overage, shortage & damage report
PSV	Pressure safety valve
P&ID	Piping and instrumentation diagram
QC/QA	Quality control/Quality assurance
RFI	Request for information
RT cranes	Rough terrain
RTS	Ready to ship
SME	Subject matter expert
SPMT	Self-propelled modular transporter

APPENDIX B: COMMITTEE MEMBERS

Committee Chair
Greg Prinsen, Fabrication Manager, Inter Pipeline

Committee Members
Ken McAlpine, Suncor, Major Projects
Colin Kosolofski, Suncor, Major Projects
Martin Clutterbuck, Independent Consultant
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