MODULE ASSEMBLY FRAMEWORK

A Best Practice Tool of the Construction Owners Association of Alberta

Version 1.0

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This Best Practice Tool was developed through a consensus development process approved by COAA. This process brings together volunteers representing varied viewpoints and interests to achieve a reasonable consensus to develop a general guideline for industry use. The content of this guidelines does not represent the views of any particular committee member. This document is a general guidelines and COAA strongly recommends legal and other professional advice being obtained to complement and clarify this guideline. This guidelines is also subject to periodic review and readers should ensure they are referencing the most current version of this guideline. Suggestions for improving this guideline are welcome and can be submitted directly to COAA.

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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 more detailed description of what a principle is as it relates to this best practice tool. The document is a high level summary based on principles, an experienced module management team is essential to interpret and implement the principles for specific project circumstances.

This document supports the COAA initiative of TWICE AS SAFE, TWICE AS PRODUCTIVE BY 2020. Anyone using 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.

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 and complexity and the 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 interrelated and readers should use it in its entirety and be cognizant that one section may relate to 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.

Please use this best practice tool for the purposes you see fit for your project and if you have any feedback we would appreciate your suggestions. You can email either of the Co-Chairs with your comments at the email addresses below.

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MODULE ASSEMBLY ELEMENTS

1.0 DESIGN

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 considering 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 its issued

2.0 PROCUREMENT

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

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

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

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

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.

7.0 LIFTING AND SHIPPING PREPARATION

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)

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

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
- Deliver modules in the site setting sequence. Early understanding is required regarding the number and arrangement of modules
- Consider path of construction and methodologies for site installation (i.e., self-propelled module transport, direct to hook, jack and roll, etc.)
- 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 impact the exclusion zone has

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)
- Ship loose material for each module should be shipped with the module if practical for ease of installation

9.5 Plan for site conditions

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

10.0 COMPLETION

10.1 Define commissioning requirements

- Have a clearly defined commissioning strategy with a turnover process that meets the requirements of this strategy
- Create 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

10.3 Prepare for tie-in scope

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

10.4 Remove temporary materials

- Clear identification for items requiring removal to be provided with markup drawing, painting or other identifier

10.5 Remediation of deficiencies

- Ship a copy of the punch list and supporting documentation with the module

APPENDIX A: DEFINITIONS AND ACRONYMS

Definitions

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

Principle: "A fundamental truth; a comprehensive law or doctrine, from which others are derived, or on which other 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	Center 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
SPMT	Self-propelled modular transporter

APPENDIX B: COMMITTEE MEMBERS

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