APPENDIX A
COMMISSIONING PLAN

CFS Leitrim Bulk Storage Facility
CFS Leitrim Ottawa

GOC Project No. NPG0921C

December 11, 2012
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Appendix 1. Construction Phase Application Forms
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Commissioning Plan

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**Project:** CFS Leitrim Bulk Storage Facility  
CFS Leitrim, Ottawa

**DCC Contract No:** ____________  
**Date:** ____________

**Plan Approved:** ____________  
Signature  
Title  
Date

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1. **Overview**

1.1 **General**

The *Commissioning Plan* is developed in draft form for the specific project during the design phase. During the design phase, the plan provides direction for the development of the site-specific commissioning specifications by the design team. During the construction phase, the plan provides direction for the commissioning tasks during construction. The plan focuses on providing support for the specifications and provides forms for the application of the commissioning process.

1.2 **Abbreviations and Definitions**

The following are common abbreviations and definitions used in this document.

1. **Abbreviations**

<table>
<thead>
<tr>
<th>CA</th>
<th>Commissioning Agent</th>
<th>GC</th>
<th>Contractor (prime)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC</td>
<td>Controls contractor</td>
<td>MC</td>
<td>Mechanical contractor</td>
</tr>
<tr>
<td>Cx</td>
<td>Commissioning</td>
<td>MCA</td>
<td>Mechanical Commissioning Agency</td>
</tr>
<tr>
<td>Cx Plan</td>
<td>Commissioning Plan document</td>
<td>PC</td>
<td>Prefunctional checklist</td>
</tr>
<tr>
<td>DC</td>
<td>Design Consultant</td>
<td>Subs</td>
<td>Subcontractors to General</td>
</tr>
<tr>
<td>EC</td>
<td>Electrical contractor</td>
<td>TAB</td>
<td>Test and balance contractor</td>
</tr>
<tr>
<td>ECA</td>
<td>Electrical Commissioning Agency</td>
<td>WWTPCA</td>
<td>Waste Water Treatment Plant Commissioning Agency</td>
</tr>
<tr>
<td>FT</td>
<td>Functional performance test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. **Definitions**

- **Acceptance Phase** - phase of construction after startup and initial checkout when functional performance tests, O&M documentation review and training occurs.

- **Approval** - acceptance that a piece of equipment or system has been properly installed and is functioning in the tested modes according to the Contract Documents.

- **Basis of Design** - The basis of design is the documentation of the primary thought processes and assumptions behind design decisions that were made to meet the design intent. The basis of design describes the systems, components, conditions and methods chosen to meet the intent.
Commissioning Agent (CA) - an independent agent, not otherwise associated with the Contractor. The CA directs and coordinates the day-to-day commissioning activities.

Commissioning Agencies – Independent commissioning companies and/or individual specializing and experienced in commissioning of specialized equipment and systems. Commissioning Agencies retained by respective Subs for Mechanical (including process), Electrical and Waste Water Treatment Plant are required for commissioning of equipment and systems.

Commissioning Plan - an overall plan, developed before or after tender period that provides the structure, schedule and coordination planning for the commissioning process.

Contract Documents - the documents binding on parties involved in the construction of this project (drawings, specifications, change orders, amendments, contracts, Cx Plan, etc.).

Datalogging - monitoring flows, currents, status, pressures, etc. of equipment using stand-alone dataloggers separate from the control system.

Deferred Functional Tests - FTs that are performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions that disallow the test from being performed.

Deficiency - a condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents (that is, does not perform properly or is not complying with the design intent).

Design Intent - a dynamic document that provides the explanation of the ideas, concepts and criteria that are considered to be very important to the owner. It is initially the outcome of the programming and conceptual design phases.

Design Narrative or Design Documentation - sections of either the Design Intent or Basis of Design.

Factory Testing - testing of equipment on-site or at the factory by factory personnel with an Owner’s representative present.

Functional Performance Test (FT) - test of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional testing is the dynamic testing of systems (rather than just components) under full operation (e.g., the heating pump is tested interactively with the heating functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system’s sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB) is not functional testing, in the commissioning sense of the word. TAB’s primary work is setting up the system flows and pressures as specified, while functional testing is verifying that which has already been set up. The commissioning agent develops the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which is usually performed by the installing contractor or vendor. FTs are performed after prefuctional checklists and startup are complete.

Indirect Indicators - indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100% closed.

Manual Test - using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the “observation”).

Monitoring - the recording of parameters (flow, current, status, pressure, etc.) of equipment operation using dataloggers or the trending capabilities of control systems.
Over-written Value - writing over a sensor value in the control system to see the response of a system (e.g., changing the outside air temperature value from 10°C to 24°C to verify economizer operation). See also “Simulated Signal.”

Owner-Contracted Tests - tests paid for by the Owner will not be repeated during functional tests if properly documented.

Phased Commissioning - commissioning that is completed in phases (by floors, for example) due to the size of the structure or other scheduling issues, in order minimize the total construction time.

Prefunctional Checklist (PC) - Inspection and elementary component tests to verify proper installation of equipment. Prefunctional checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels OK, labels affixed, gages in place, sensors calibrated, etc.). However, some prefunctional checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor of a chiller system). The word prefunctional refers to before functional testing. Prefunctional checklists augment and are combined with the manufacturer’s start-up checklist. Contractors to prepare and execute the checklists. The commissioning agent requires that the procedures be documented in writing. CA will witness prefunctional checklisting.

Seasonal Performance Tests - FT that are deferred until the system(s) will experience conditions closer to their design conditions.

Simulated Condition - condition that is created for the purpose of testing the response of a system (e.g., applying a hair blower to a space sensor to see the response in a VAV box).

Simulated Signal - disconnecting a sensor and using a signal generator to send an amperage, resistance or pressure to the transducer and DDC system to simulate a sensor value.

Startup - the initial starting or activating of dynamic equipment, including executing prefunctional checklists.

Test Procedures - the step-by-step process which must be executed to fulfill the test requirements. The test procedures are developed by the CA.

Test Requirements - requirements specifying what modes and functions, etc. shall be tested.

Vendor - supplier of equipment.

Warranty Period - warranty period for entire project, including equipment components. Warranty begins at Substantial Completion and extends for at least one year, unless specifically noted otherwise in the Contract Documents and accepted submittals.

1.3 Purpose of The Commissioning Plan

The purpose of the construction phase commissioning plan is to:

1. Provide direction for the commissioning process during construction, particularly providing resolution for issues and providing details that cannot be, or were not, fully developed during design, such as scheduling, participation of various parties of this particular project, actual lines of reporting and approvals, coordination, etc.

This plan does not provide a detailed explanation of required testing procedures. The detailed testing requirements and procedures are found in the Specifications. Additionally, this plan does not provide extensive narrative on all commissioning concepts, as may be provided in other commissioning guides.
Commissioning Scope

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent. This is achieved by beginning in the design phase, documenting the design intent and continuing through construction, acceptance and the warranty period with actual verification of performance.

Commissioning during the construction of this project is intended to achieve the following specific objectives:

According to the Contract Documents:

- Ensure that applicable equipment and systems are installed properly and receive adequate operational checkout by installing contractors.
- Verify and document proper performance of equipment and systems.
- Ensure that O&M documentation is complete.
- Ensure that the Owner’s operating personnel are adequately trained.

Commissioned Systems

The following marked systems will be commissioned in this project. Refer to Section 6 for additional details. All general references to equipment in this document refer only to equipment that is to be commissioned.

1. Fire Protection Systems
   a. Diesel and electric fire pumps
   b. Dry sprinkler system

2. Plumbing Systems
   a. Piping and valves
   b. Domestic Hot Water
   c. Cold water storage tank/pump
   d. Pumps
   e. Plumbing specialties
   f. Plumbing fixtures

3. Drainage systems
   a. Sanitary
   b. Storm
   c. Septic Tank and Field

4. Compressed Air System

5. Propane gas heating system
   a. Propane tank and accessories
   b. Piping and valves
   c. Specialties and accessories

6. Electric heating
7. Equipment vibration and seismic installation  
8. Mechanical identification system for equipment and systems  
9. Refrigerant Systems  
10. Unit heaters.  
11. Fans.  
12. DX cooling systems and associated condenser units.  
13. Furnaces  
14. Gas sensors and associated controls  
15. HVAC controls  
54. Electrical Systems:  
   a. Power Distribution Systems and outlets  
   b. Motor Controls and Equipment connections  
   c. Lighting  
   d. Telecommunication  
   e. Fire Alarm System  
   f. Instrumentation Controls  

1.6 Forms  
Forms used during commissioning are referred to in this plan.  

2. General Building Information  
Project: CFS Leitrim Bulk Storage Facility  
Location: CFS Leitrim, Ottawa  
Building Type: Storage
3. **Commissioning Team Data**

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Co. &amp; Contact Names</th>
<th>Voice, office, cell, fax, email, address</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Owner</strong></td>
<td>Department of National Defence (DND)</td>
<td></td>
</tr>
<tr>
<td>DND Project Manager (DND PM)</td>
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<td></td>
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<tr>
<td>DND Deputy Project Manager</td>
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<tr>
<td>DND Project Officers (DND</td>
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<tr>
<td>PO)</td>
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<tr>
<td>Canadian Forces Fire</td>
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<tr>
<td>Marshall (CFFM)</td>
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<td>Base Construction and</td>
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<td><strong>Engineer</strong></td>
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<td>DCC Site Coordinators</td>
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<tr>
<td><strong>Contractor</strong></td>
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<tr>
<td>Project Manager</td>
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<tr>
<td>Quality Manager</td>
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<tr>
<td><strong>Commissioning Agent</strong></td>
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<tr>
<td><strong>Design Consultant</strong></td>
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<td>Design Manager &amp; Lead</td>
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<tr>
<td>Site Superintendent</td>
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<tr>
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<tr>
<td>Team Member</td>
<td>Co. &amp; Contact Names</td>
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<tr>
<td>Commissioning Coordinator</td>
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<td>Site Superintendent.</td>
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<tr>
<td>Crane Commissioning Coordinator</td>
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</table>
4. Roles and Responsibilities

4.1 Commissioning Team Organization and Formal Lines of Communications

TO BE DEVELOPED AFTER CONTRACT AWARD

4.2 General Management Plan
In general, the CA coordinates the commissioning activities and reports to the Engineer. The CA’s responsibilities, along with all other contractors’ commissioning responsibilities are detailed in the specifications. The Specifications will take precedence over this Cx Plan. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents. Refer to the management protocols section below.

4.3 General Descriptions of Roles
General descriptions of the commissioning roles are as follows:

- **CA**: Coordinates the Cx process, writes tests, oversees and documents performance tests and witnesses prefunctional checklisting.
- ** Commissioning Agencies**: Retained by respective Subs to plan and carry out commissioning of the respective systems on their behalf.
- **Engineer**: Facilitates the Cx process. Approves test plans and signs-off on performance.
- **GC**: Facilitates the Cx process, ensures that Subs perform their responsibilities and integrates Cx into the construction process and schedule.
- **Subs**: Verify proper installation of equipment and Demonstrate proper system performance.
- **Design Consultant**: Performs construction observation, approve O&M manuals and assist in resolving problems.
- **DND PM**: Facilitates and supports the Cx process and gives final approval of the Cx work.
- **Mfr.**: The equipment manufacturers and vendors provide documentation to facilitate the commissioning work and perform contracted startup.

5. Commissioning Process
This section sequentially details the commissioning process by commissioning task or activity.

5.1 Commissioning Scoping Meeting
A commissioning scoping meeting will be planned and conducted by the CA within 90 days of the beginning of construction. The respective representatives of the Commissioning Team identified above will attend the meeting. The following will be carried out in the Scoping meeting:

- Commissioning parties will be introduced;
• Commissioning process will be reviewed;
• Management and reporting lines will be established;
• Document flow will be discussed to determine how much submittal data the CA and others will receive, etc.;
• The Cx Plan will be reviewed, process questions addressed, lines of reporting and communications determined and the work products list discussed;
• Each party’s responsibilities will be reviewed including who is responsible to develop the startup plan for each piece of equipment, commissioning forms, and the proposed commissioning schedule;

The outcome of the meeting will increase understanding by all parties of the commissioning process and their respective responsibilities. The meeting will provide the CA additional information needed to finalize the Cx Plan, including the commissioning schedule.

The CA will issue minutes of the meeting.

5.2 Final Commissioning Plan

The CA will finalize the draft Cx Plan using the information gathered from the scoping meeting. The initial commissioning schedule will also be developed (Table 8-1) along with a detailed timeline using Form C-10, Detailed Commissioning Schedule. The timeline will be fine-tuned as construction progresses. In particular, 60 days prior to startup of the primary equipment, the CA will meet with the GC and Engineer and develop a detailed commissioning schedule. The commissioning plan will be approved by the Engineer.

5.3 Site Observation

The CA, and Engineer will visit the site, as necessary, to witness equipment and system installations.

5.4 Miscellaneous Meetings

The CA will attend selected planning and job-site meetings in order to remain informed on construction progress and to update parties involved in commissioning. The Engineer and GC will provide the CA with information regarding substitutions, change orders and any Supplemental Instructions (SI) that may affect commissioning equipment, systems or the commissioning schedule. The CA may review construction meeting minutes, change orders or SIs for the same purpose.

Later during construction, necessary meetings between various commissioning team parties will be scheduled by the CA, through the Engineer, as required.

5.5 Management Protocols

The following protocols will be used on this project.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>For requests for information (RFI) or formal documentation requests:</td>
<td>The CA goes first: DC through the Engineer, Subs through GC.</td>
</tr>
<tr>
<td>For minor or verbal information and</td>
<td>The CA goes direct to the informed party.</td>
</tr>
</tbody>
</table>
clarifications:

For notifying contractors of deficiencies: The CA documents deficiencies through the Engineer, but may discuss deficiency issues with contractors prior to notifying the Engineer.

For scheduling functional tests or training: The CA may provide input for and do some coordination of training and testing, but does not do any scheduling.

For scheduling commissioning meetings: The CA selects the date and schedules, coordinates with the Engineer and GC and notifies attendees directly.

For making a request for significant changes: The CA has no authority to issue change orders. Such requests will be forwarded to Engineer for action.

For making small changes in specified sequences of operations: The CA shall obtain approval of the Engineer and DC prior to making small sequences of operations changes to improve efficiency or control or to correct deficiencies, through the responsible contractor. The CA will document such changes and provide all changes of specified sequences to the Engineer and DC.

Subcontractors disagreeing with requests or interpretations by the CA shall: Try and resolve with the CA first. Then work through GC who will work with CA directly or through the Engineer to resolve the situation.

Additional protocols regarding the flow of documents and the commissioning process are shown in Appendix 2.

5.6 Progress Reporting and Logs

At the beginning of construction, the CA will provide the Engineer with monthly commissioning progress reports. Thirty (30) days prior to the startup of the first piece of major equipment, the frequency of progress reports will be increased to twice per month, until startup is completed. Thirty (30) days before functional testing of equipment begins, weekly progress reports will be required until functional testing and all non-conformance issues are resolved. The Engineer may adjust the reporting frequency as needed. The progress reports will contain: an update of the schedule with list of requested schedule changes and new items added to the schedule, a list of new and outstanding deficiencies, a description of commissioning progress corresponding to the plan, etc. Form C-4, Commissioning Progress Report provides a format for this report. The CA will keep a log of all commissioning-related issues that require current or future attention using Form C-1, Commissioning Issues Log. Form C-7 Commissioning Progress Record provides a form for tracking the status of documentation and testing for each piece of equipment and system (e.g., installer, party responsible for startup, approval dates for checklist and testing forms, their completion, training, O&M documentation review, etc.).

The CA will regularly communicate with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling issues through memos, progress reports, etc. (Form C-3e, Commissioning Memorandum).

The CA will keep all commissioning materials in an organized notebook. An example format is illustrated in Form C-17, Sample Commissioning Record Notebook Format, in Appendix 1.
5.7 Initial Submittals and Documentation

5.7.1 Standard Submittals

The CA will provide all Subs responsible for commissioned equipment with commissioning documentation requirements for their respective equipment and systems through the Engineer. This data request will typically coincide with the normal DC submittal process. At minimum, this equipment data will include installation and start-up procedures, O&M data, performance data and control drawings. The CA will review and approve submissions relative to commissioning issues expressed in the contract documents, not for general contract compliance (which is the DC’s responsibility), unless specifically directed by the Engineer to do so. Form C-2, Request for Documentation and Record of Submissions for Commissioning provides documentation request and tracking forms for representative equipment and acts as the tracking mechanism for documentation. It can also be used as the checkoff sheet for part of the final O&M documentation review. CA recommendations will be provided to the Engineer.

5.7.2 Special Submittals, Notifications and Clarifications

The Subs, GC or DC will notify the Engineer and CA of any new design intent or operating parameter changes, added control strategies and sequences of operation, or other change orders that may affect commissioned systems. The controls contractor will provide the CA a full points list with details requested by the CA (see Specification Divisions 25 and 40). Thirty (30) days prior to performing owner-contracted tests, the Subs will provide the CA full details of the procedures. As the phases of the TAB are completed, the draft TAB report will be provided to the CA with full explanations of approach, methods, results, data table legends, etc. The final TAB report will be provided to the CA upon completion.

These submittals to the CA do not constitute compliance for submittals for the O&M manuals. Documentation requirements for the O&M manuals are discussed in Section 5.11, herein.

The CA through Engineer may request additional design narrative from the DC and from the controls contractor. The CA may submit written RFIs to contractors through the Engineer, (Form C-3d, Commissioning Request for Information) or address them directly for clarifications, as needed.

5.8 Prefunctional Checklists, Tests and Startup

Prefunctional checklists (PC) are important to ensure that the equipment and systems are hooked up and operational and that functional performance testing may proceed without unnecessary delays. Each piece of equipment will receive full prefunctional checkout by the Contractor. No sampling strategies will be used. In general, the prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.

Prefunctional checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., oil levels OK, fan belt tension, labels affixed, gages in place, sensor calibration, etc.). However, some prefunctional checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor of a chiller system). The word prefunctional refers to before functional testing. Prefunctional checklists augment and are combined with the manufacturer’s start-up checklist.
On this project the procedures for the execution of these checklist items will be documented in writing by the installing technician. The CA will witness all of the prefunctional checklisting.

5.8.1 Start-up Plan

The CA will assist the commissioning team members responsible for startup in developing detailed startup plans for all equipment. The parties responsible for each part of startup and initial checkout will be identified in Form C-7 Commissioning Progress Record and on the prefunctional checklists. Refer to Appendix 2, Chart 1 for a graphic description of how the prefunctional checklist and start-up plans are developed. Chart 3 in Appendix 2 shows a submittal map for reference.

The following procedures will be used for this project:
1. The CA will adapt and enhance, if necessary, the representative prefunctional checklists (PC) and procedures from the lists in Specification Section 23 08 00, and develops original lists, as necessary.
2. The CA will transmit them to the GC who will designate which trade or contractor is responsible to fill out each line item (mark in the “Contr” column) on the Prefunctional Checklist from the CA. The GC will then transmit the checklist to the responsible Subs.
3. The Sub designated to develop the Start-up Plan will obtain manufacturer installation, start-up and checkout data, including actual field checkout sheets used by the field technicians.
4. The Sub will copy all pages with important instructional data and procedures (not covered in manufacturer field checkout sheets) from the start-up and checkout manuals and add a signature line in the column by each procedure.
5. The copied pages from (2), along with the prefunctional checklist provided by the GC (originally from the CA) and the manufacturer field checkout sheets will become the “Start-up and Checkout Plan.” Form C-8, Plan and Documenting Requirements for Startup, provides a cover sheet and template for the start-up plan.
6. For systems that may not have adequate manufacturer start-up and checkout procedures, particularly for components being integrated with other equipment, the Sub shall provide the added necessary detail and documenting format to the CA for approval, prior to execution.
7. The Sub will transmit the full Start-up Plan to the CA for review and approval.
8. The CA will review and approve the procedures and the format for documenting them using a standard form (Form C-3a or b, Commissioning Test or Review Approval or Commissioning Prefunctional Checklist and Startup Submittal / Approval), noting any procedures that need to be added, and will convey to the GC. The GC will then transmit the full start-up plan to the Subs for their review and use. (This usually means that the Prefunctional Checklist, alone, will go to more than one Sub, while the full plan will go to the primary installing contractor.)

5.8.2 Execution of Checklists and Startup

Four weeks prior to startup, the Subs and vendors will schedule startup and initial checkout with the Engineer, GC and CA. The startup and initial checkout will be directed and executed by the Sub or vendor. The CA and Engineer will observe the procedures for each piece of equipment.

To document the process of startup and checkout, the site technician performing the line item task will initial and date each paragraph of procedures in the “Startup Plan” and check off items on the prefunctional and manufacturer field checkout sheets, as they are completed. Only individuals having direct knowledge of a line item being completed shall check or initial the forms.
The Subs and vendors will execute the checklists and tests and submit a signed copy of the completed start-up and prefunctional tests and checklists to the CA, using Form C-3a or b. The CA will review prefunctional checklists in progress.

5.8.3 Deficiencies and Non-Conformance

The Subs will clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully at the bottom of the procedures form or on an attached sheet. The procedures form and deficiencies will be provided to the CA within two days of test completion. The CA will work with the Subs and vendors to correct and retest deficiencies or uncompleted items, involving the Engineer and others as necessary. The installing Subs or vendors will correct all areas that are deficient or incomplete according to the checklists and tests. The CA will recommend approval of the startup and initial checkout of each system to the Engineer using Form C-3a. Refer to Appendix 2, Chart 5 for a flow chart of the documentation process.

5.8.4 Phased Commissioning

Because of project size, this project may require startup and initial checkout to be executed in phases. The phasing is summarized in Form C-12, Phased Commissioning, in Appendix 1.

5.8.5 TAB

The TAB contractor will submit the outline of the TAB plan and approach to the CA and the controls contractor eight weeks prior to starting the TAB. Included in the approach, will be an explanation of the intended use of the building and industrial control systems. The CA will review the plan and approach for understanding and coordination issues and may comment, but does not “approve.” The controls contractor reviews the feasibility of using the building and industrial control systems for assistance in the TAB work. The TAB will submit weekly written reports of discrepancies, contract interpretation requests and lists of completed tests to the CA and Engineer. This will facilitate quicker resolution of problems and result in a more complete TAB before functional testing begins.

TAB work will not begin until the control system has been prefunctionally tested and selective functional tests have been performed and approved by the CA.

5.8.6 Controls Checkout Plan

The controls contractor will develop and submit a written step-by-step plan to the CA which describes the process they intend to follow in checking out the control systems and the forms on which they will document the process. The controls contractor will also meet with the TAB contractor prior to the start of TAB and review the TAB plan to determine the capabilities of the control system for use in TAB. The controls contractor will provide the TAB with any necessary unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.). The controls contractor shall also provide a technician qualified to operate the controls to assist the TAB contractor in performing TAB.

All CA-required controls prefunctional checklists, calibrations, start-up and selected functional tests of the system shall be completed and approved by the CA prior to TAB. The controls contractor shall execute the tests and trend logs assigned to them as specified and remain on site for assistance for mechanical & process systems functional tests.
5.9 Development of Functional Test and Verification Procedures

5.9.1 Overview

Functional testing is the dynamic testing of systems (rather than just components) under full operation (e.g., the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all of the control system’s sequences of operation and components are verified to be responding as the sequences state. The commissioning agent will develop the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which will be performed by the installing contractor or vendor.

5.9.2 Scope of Testing

A detailed description of the functional and prefunctional testing procedures and process is found in the Specifications, 01 91 31 Part 3. Testing requirements are also include in each technical specification section, where appropriate. If specific testing requirements are not included in the tender documents and original specifications, then such requirements will be developed for this project for each piece of commissioned equipment. Another example format that may be useful is illustrated in Form C-15, Functional Testing Scope Outline.

5.9.3 Development Process

Before test procedures are written, the CA will obtain all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, control sequences and setpoints. The CA will develop specific test procedures to verify proper operation of each piece of equipment and system, using the testing requirements specified in the Specifications and other sources. The CA will obtain clarification, as needed, from contractors and the DC regarding sequences and operation to develop these tests. Prior to execution, the CA will provide a copy of the primary equipment tests to the installing Sub (via the GC) who will review the tests for feasibility, safety, warranty and equipment protection. Blank copies of the procedures will be input into the O&M manuals for later use by operations staff. Refer to Appendix 2, Chart 2 for an illustration of the development of functional test forms and Chart 4 for the functional test submittal map.

Functional testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system’s trend log capabilities or by stand-alone dataloggers. The CA will follow the Specifications when given and use judgment where needed to determine which method is most appropriate. The CA will review owner-contracted, factory or required owner acceptance tests and determine what further testing may be required to comply with the Specifications.

Form C-13, Owner Contracted Tests, lists the owner-contracted or conducted tests for which the CA will not write procedures or document execution. Included in Form C-13 is the CA’s judgment as to the rigor of the tests and the need for more in-depth testing. The CA will review and approve documentation format of these tests prior to execution, but will not develop the procedures or document their execution, unless so requested by the Engineer.

5.9.4 Testing Plan Overview

To provide the contractors with a better idea of where functional testing lies in the schedule, what issues may prevent the start of testing, which contractors may be needed for each test and how much time
might be expected from them, Form C-11, Commissioning Functional Testing Plan Overview, will be used. This form will be filled out after most equipment has been started up and when functional testing dates are not too far off. The form will be provided to the Contractors to assist in moving more efficiently to functional testing.

5.10 Execution of Functional Testing Procedures

5.10.1 Overview and Process

The CA will schedule functional tests through the Engineer, GC and affected Subs. For any given system, prior to performing functional testing, the CA will wait until the prefunctional checklist has been submitted with the necessary signatures, confirming that the system is ready for functional testing. The CA will oversee, witness and document the functional testing of all equipment and systems according to the Specifications and the Cx Plan. The Subs execute the tests. The control system will be tested before it is used to verify performance of other components or systems. The air balancing and water balancing will be completed and debugged before functional testing of air-related or water-related equipment or systems. Testing will proceed from components to subsystems to systems and finally to interlocks and connections between systems. Refer to Section 6 for details on functional testing scope. Refer to Appendix 2, Chart 5, for a flow chart of the documentation process.

5.10.2 Deficiencies and Retesting

The CA will document the results of the test. Corrections of minor deficiencies identified will be made during the tests at the discretion of the CA. The CA will record the results of the test on the procedure or test form. Deficiencies or non-conformance issues will be noted and reported to the Engineer on Form C-6 (Commissioning Corrective Action Report). Subs will correct deficiencies, notify the CA and return Form C-6 certifying correction. The CA will schedule retesting through the Engineer. Decisions regarding deficiencies and corrections will be made at as low a level as possible, preferably between CA and the Sub. For areas in dispute, final authority, besides the Owner’s, resides with the Engineer. The CA will recommend acceptance of each test to the Engineer. The Engineer will give final approval on each test using Form C-3a or b (Commissioning Test or Review Approval or Commissioning Prefunctional Checklist and Startup Submittal / Approval) form. For tracking, Form C-7, Commissioning Progress Record, is provided which lists all tests and their status.

5.10.3 Facility Staff Participation

The Owner’s facilities operating and maintenance staff will be encouraged to attend and participate in the testing process. The tables in Form C-14, Facility Staff Participation, summarize the planning of their involvement. This form does not describe their involvement in formal training. The CA will notify the Engineer and DND PM, who will then notify the facility staff when the commissioning events will occur.

5.10.4 Phased Testing

Refer to Section 5.8.4 for details regarding testing the equipment or systems in phases.

5.11 O&M Manuals and Warranties

5.11.1 Standard O&M Manuals

The CA will review the O&M manuals, documentation and redline as-builts for systems that were commissioned to verify compliance with the Specifications. The CA will recommend approval and acceptance of these sections of the O&M manuals to the Engineer. The CA will also review each equipment warranty and verify that all requirements to keep the warranty valid are clearly stated.
5.11.2 Commissioning Record

The CA will compile, organize and index the following commissioning data by equipment into labeled, indexed and tabbed, three-ring binders and deliver it to the GC, to be included with the O&M manuals. The correspondence, meeting minutes and progress reports, miscellaneous notes, etc. kept in the Commissioning Record Book during construction will not be retained into this record and the O&M manuals. The format of the manual follows:

General

| Tab I-1    | Commissioning Plan |
| Tab I-2    | Final Commissioning Report |
| Tab I-3    | Issues Log (record of deficiencies, Form C-1) |
| Tab I-4    | Progress Record (Form C-7) |

Equipment Specific

| Tab 01    | System Type 1 (chiller system, packaged unit, boiler system, etc.) |
| Sub-Tab A | Design narrative and criteria, sequences, approvals for Equipment 1 |
| Sub-Tab B | Start-up plan and report, approvals, corrections, blank prefunctional checklists |
|           | Colored Separator Sheets—for each equipment type (fans, pumps, chiller, etc.) |
| Sub-Tab C | Functional tests (completed), trending and analysis, approvals and corrections, training plan, record and approvals, blank functional test forms and a recommended recommissioning schedule. |

| Tab 02    | System Type 2......repeat as per System One |

5.12 Training and Orientation of Owner Personnel

Owner training and orientation on equipment and systems provided by the Contractor will be accomplished in three general steps using three forms.

1. **Overall Plan.** After reviewing the specifications, and after interviewing facility staff, if necessary, the Owner and Commissioning Agent (CA) will fill out a table listing all the equipment for which training or orientation will be provided, on Form C-5a, Project Training Plan—General Scope and Responsible Parties. This form will list, among other things, the type and number of trainees, rigor of training desired by the Owner, the primary responsible subcontractor, the trainer’s company and columns for tracking training agendas. The Commissioning Agent will provide this form to the Contractor for reference.

2. **Specific Training Agendas.** For each piece of equipment or system for which training is provided, the Owner and CA will fill out Section 1 of the Training and Orientation Agenda, Form C-5b. This section will include some of the information from Form C-5a, regarding the scope of training and the intended audience, for reference by the trainer in developing the training agenda. The CA will develop a plan including in the training session contractors / trainers from different disciplines, when appropriate, by listing their company names in Section 2 of the form. In particular, the controls contractor will provide brief training on controls in the same session with the mechanical training for equipment controlled by the building automation system.

   This form will then be submitted to the Contractor who will have the trainer fill out the rest of Sections 2 and 3 of the form (Form C-5b), describing the subjects covered, duration of each subject
and the methods that will be used in the training, along with the name and qualifications of the trainer(s). The trainer will return this form to the Contractor, who will submit it to the Owner and CA. The Owner and CA will review the agenda; make comments; approve the form subject to the comments; and submit back to the Contractor. The Contractor will provide the approved agenda to the trainer to use during the training. The trainer will provide a copy of the agenda to each trainee.

3. Training Record. For each piece of equipment, prior to training, the Contractor will provide each trainer Form C-5c, *Training and Orientation Record*. On this form, the trainer will document each training session (duration and general subjects covered). The trainer will sign for the session and obtain the signature of each trainee. The trainer will also check off subjects covered on the Agenda (Form C-5b). When the training is complete, the Contractor will provide a copy of the *Training and Orientation Record*, Form C-5c, and the trainer’s Agenda, Form C-5b to the Owner and CA. The Owner and CA will review C-5c and make final approval by signing it. The CA will attend all of the training sessions.

5.12.1 Special Training and Orientation

The following checked orientation and trainings will be completed by the CA and DC according to the specifications:

1. Recommissioning. The CA will provide instructions on the use of blank functional test forms for periodic recommissioning of equipment and systems, per the specification.

2. Design Consultant. The DC will provide:
   - A general overview of the facility, its use, special features, user considerations, etc.
   - An overview of the major systems and equipment in the facility, including for each system: the design intent, why the system was chosen, an overview of its operation, and interactions with other systems, any special areas to be aware of, issues regarding future expansion and remodeling, etc.
   - An overview of the major electrical systems and equipment in the facility, particularly the lighting control systems, fire alarm, security and emergency power, focusing on the design intent, why the system was chosen, an overview of its operation, and interactions with other systems, any special areas to be aware of, issues regarding future expansion and remodeling, etc.

5.13 Warranty Period

During the warranty period, seasonal testing and other deferred testing required will be completed according to the Specifications. The CA will coordinate this activity. Tests will be executed and deficiencies corrected by the appropriate Subs, witnessed by facilities staff and the CA. Any final adjustments to the O&M manuals and as-buils due to the testing will be made. In addition the CA will return to the project approximately 10 months into the 12 month warranty period. During this visit(s) the CA will review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal commissioning. The CA will also interview facility staff and identify problems or concerns they have operating the building as originally intended. The CA will make suggestions for improvements and for recording these changes in the O&M manuals. The CA will identify areas that may come under warranty or under the original construction contract. The CA will also assist facility staff in developing reports and documents and requests for services to remedy outstanding problems.
6. **Written Work Products**

The written work products from all parties are described in Form C-16, *Formal Written Work Products*. The table describes each product, who is responsible for producing it, the general due date, the parties who receive it and who approves it, etc.

6.1 **Summary Report**

A final summary report by the CA will be provided to the Engineer and DND PM. The report shall include an executive summary, list of participants and roles, brief building description, overview of commissioning and testing scope and a general description of testing and verification methods. For each piece of commissioned equipment, the report should contain the disposition of the CA regarding the adequacy of the equipment, documentation and training meeting the contract documents in the following areas:

1. Equipment meeting the equipment specifications,
2. Equipment installation,
3. Functional performance and efficiency,
4. Equipment documentation and design intent, and
5. Operator training. All outstanding non-compliance items shall be specifically listed. Recommendations for improvement to equipment or operations, future actions, commissioning process changes, etc. shall also be listed. Each non-compliance issue shall be referenced to the specific functional test, inspection, trend log, etc. where the deficiency is documented. The functional performance and efficiency section for each piece of equipment shall include a brief description of the verification method used (manual testing, BAS trend logs, data loggers, etc.) and include observations and conclusions from the testing.

Appendices shall contain acquired sequence documentation, logs, meeting minutes, progress reports, deficiency lists, site visit reports, findings, unresolved issues, communications, etc. Prefunctional checklists and functional tests (along with blanks for the operators) and monitoring data and analysis will be provided in a separate labeled binder.

The commissioning plan, the prefunctional checklists, functional tests and monitoring reports will not be part of the final report, but will be stored in the Commissioning Record in the O&M manuals.

7. **Schedule**

7.1 **General Issues**

The following sequential priorities will be followed:

1. Equipment will not “temporarily” started (for heating or cooling), until pre-start checklist items and all manufacturers’ pre-start procedures are completed and moisture, dust and other environmental and building integrity issues have been addressed.

2. Functional testing will not commence until prefunctional and start-up and TAB is completed, for a given system (this does not preclude a phased approach).
3. The controls system and equipment it controls will not be functionally tested until all points have been calibrated and pre-functional testing completed.

4. TAB will not be performed until the controls system has been functionally tested and approved by the CA for TAB work.

5. TAB will not be performed until the envelope is completely enclosed and ceiling completed, unless the return are ducted.

7.2 Project Schedule
The initial commissioning schedule is summarized in Table 7-1. A more detailed schedule is contained in Form C-10, *Detailed Commissioning Schedule*, in Appendix 1.

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<thead>
<tr>
<th>Task / Activity</th>
<th>Estimated Start Date</th>
<th>Estimated End Date</th>
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</thead>
<tbody>
<tr>
<td>Initial scoping meeting and final plan</td>
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<tr>
<td>Submittals obtained and reviewed</td>
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<tr>
<td>Begin construction site visits/inspections</td>
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<td>Prefunctional forms developed and distributed</td>
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<tr>
<td>Startup and initial checkout plans</td>
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<td>TAB Air</td>
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<td>Functional performance tests</td>
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<td>Training and training verification</td>
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<td>Final commissioning report</td>
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<td>Seasonal testing</td>
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