AABC Commissioning Group
AIA Provider Number 50111116

Case Study: Re-Commissioning an Industrial Gas Chiller

Course Number: CXENERGY1831

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North Slope Borough, Department of Capital Improvement Program Management
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Coffman Engineers, Inc.

April 26, 2018

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Course Description

This case study examines re-starting, re-commissioning, and optimizing an industrial gas chiller used for drying well-head natural gas. It validates building commissioning processes in non-building applications. The project applies building commissioning to a piece of industrial equipment. The recommissioning led to a new OPR, an operational hazard analysis, design review, installation verification, and testing as well as planning, documentation, and training. The completed project transformed a non-performing investment into a system that exceeded expectations.

Learning Objectives

At the end of the this course, participants will be able to:

1. Learn the difference between startup processes and commissioning processes, in this case the recommissioning leading to a new OPR, an operational hazard analysis, design review, installation verification, and testing as well as planning, documentation, and training.

2. Learn the importance of using all the steps in the commissioning process and not cutting corners. Understand that the commissioning process, by design, incorporates measures that optimize mechanical, electrical, plumbing and fire protection that provide many benefits beyond immediately apparent operations.

3. Understand how the CxA can apply building commissioning processes to non-building applications.

4. Understand the importance of including the commissioning requirements properly in the project specifications so that all benefits to mechanical systems are assured, documentary requirements are met, and compliance with relevant regulations, standards, laws and ordinances is met.

Get the whole story

ReCommissioning an Industrial Gas Chiller

Today's Presentation

- **Who we are**
  - Owner and consultant
- **What is this thing?**
  - The Alaska Factor
  - The Chiller
- **Why ReCommission?**
  - The Owner's Perspective

ReCommissioning an Industrial Gas Chiller

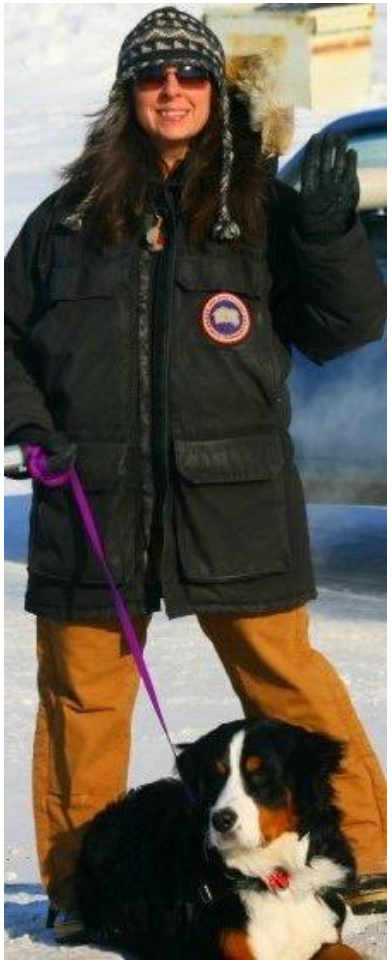
Today's Presentation

- **The ReCommissioning process;**
  - Compare Cx to ReCx
- **System challenges**
  - Initial findings
  - Follow-on projects
- **Conclusions**
  - What's next

ReCommissioning an Industrial Gas Chiller

Who We Are

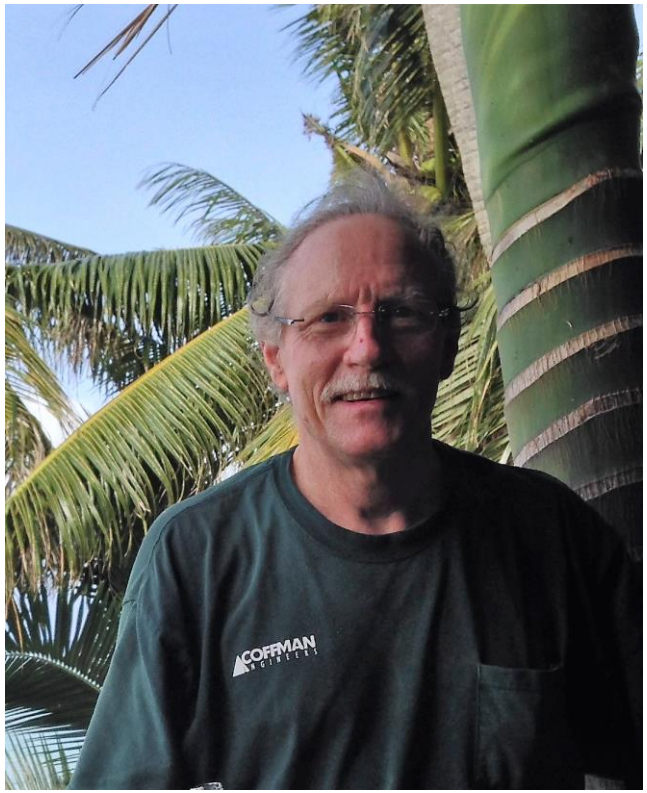
- **Melissa Bynum, Project Manager** for Capital Improvement Program Management for the North Slope Borough, AK
  - Issued contract solicitation
  - Managed contract scope and budget
  - Participated in OPR development



ReCommissioning an Industrial Gas Chiller

Who We Are

- **Walter Heins, PE, CxA, CCP**
  Commissioning Consultant
  - Developed project approach
  - Facilitated OPR
  - Developed Cx Plan
  - Facilitated all field activities



ReCommissioning an Industrial Gas Chiller

Who We Are

- **The Commissioning Team**
  - Commissioning Consultant
    - Mechanical, Electrical
    - Manufacturer's Engineer
  - Gas Field Operator
  - Subcontractors
    - Refrigeration contractor
    - PLC Integrator

ReCommissioning an Industrial Gas Chiller

- The Alaska Factor
- Barrow now known as Utqiagvik, is the most Northern City in the United States.
- Located 320 Miles North of the Arctic Circle.
- Utqiagvik population of 4,933.

ReCommissioning an Industrial Gas Chiller

- No Road! All freight comes by ship (summer) or air.

ReCommissioning an Industrial Gas Chiller

- Approximately 94,000 square miles
  - Climate ranges from -30 below in the Winter and 40 to 70 above in the Summer.
  - Includes 8 villages that range in population of 200 to 4,933.

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- Sun sets on Nov. 18 and doesn't come up for 65 days.

- Midnight Sun in May
- We have Polar Bears!

ReCommissioning an Industrial Gas Chiller

- We don't live in Igloos. We have real homes.

- Natural Gas is our only fuel for heat, electricity, and the water/sewer plant.
- Homes are built on pilings to preserve the permafrost.

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Why ReCommission?

- We had a Chiller Skid that didn't run and we couldn't figure out why?
- We needed the chiller to dry out our gas so it can be processed and delivered to all the residences in Barrow (Utqiagvik)

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Why ReCommission?

- Chiller Skid was constructed and installed in 2009 and ran seasonally
- After the first season Chiller Skid started to fail. Operators left it off and bypassed the Chiller using our Primary building.

ReCommissioning an Industrial Gas Chiller

- Contracted with Coffman to find the problem.
- Discovered missing lubrication management components.
- Without these key components the Chiller Skid wouldn't work properly.

17-Mile Gas Pipeline

ReCommissioning an Industrial Gas Chiller

- We also needed a way to transmit operating data to the operation center.
- Installation of a control module included a PLC/HMI and eventually SCADA.

Local Control Panel
(Gas Line Overhead)

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What is this thing?

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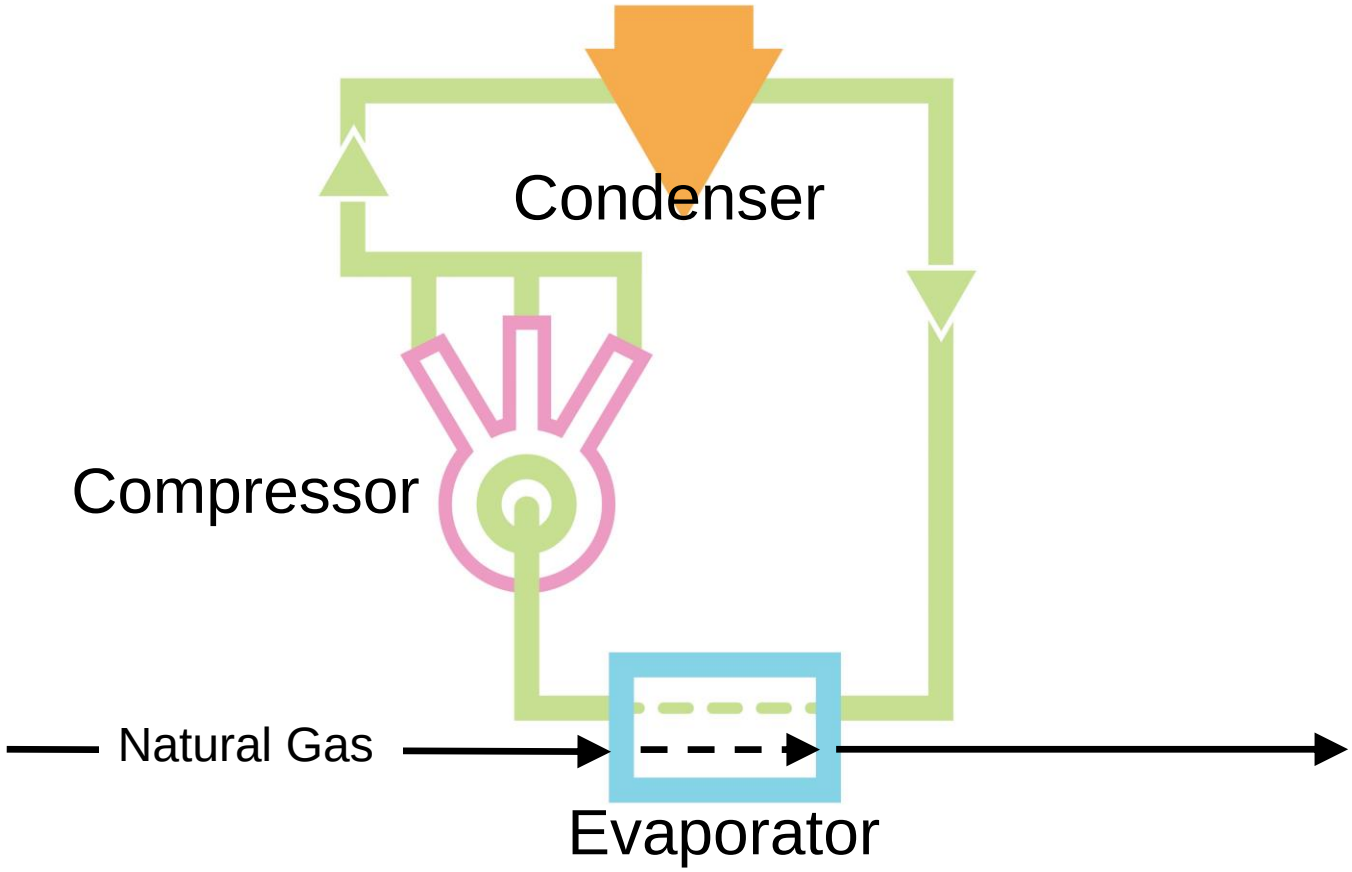
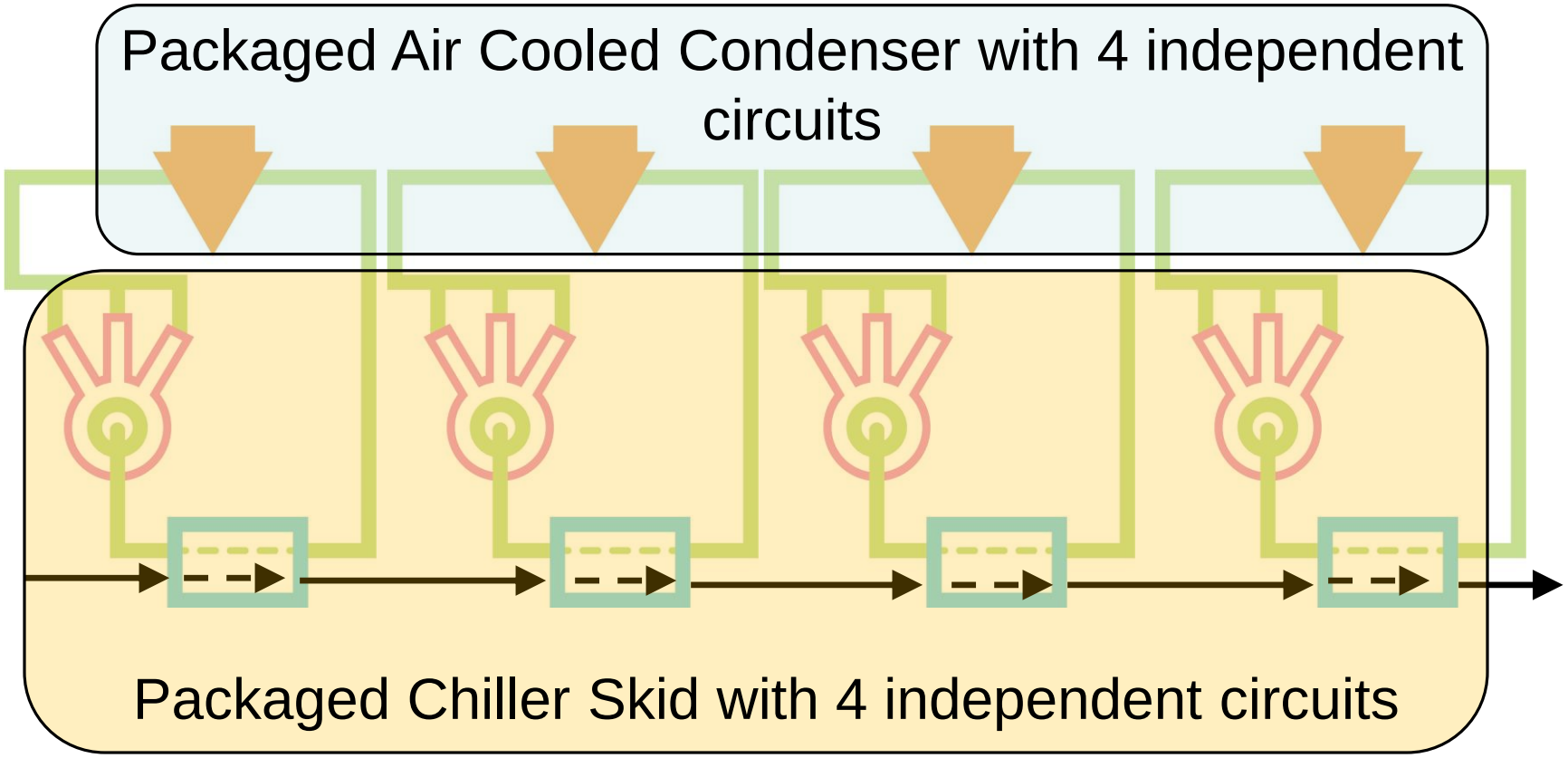
ReCommissioning an Industrial Gas Chiller



Natural Gas Chiller

ReCommissioning an Industrial Gas Chiller



Refrigerates Raw Natural Gas

ReCommissioning an Industrial Gas Chiller

Initial Commissioning

Structure and Plan

- No specification for inspection or testing
- No specification for training
- No specification for O&M Manuals

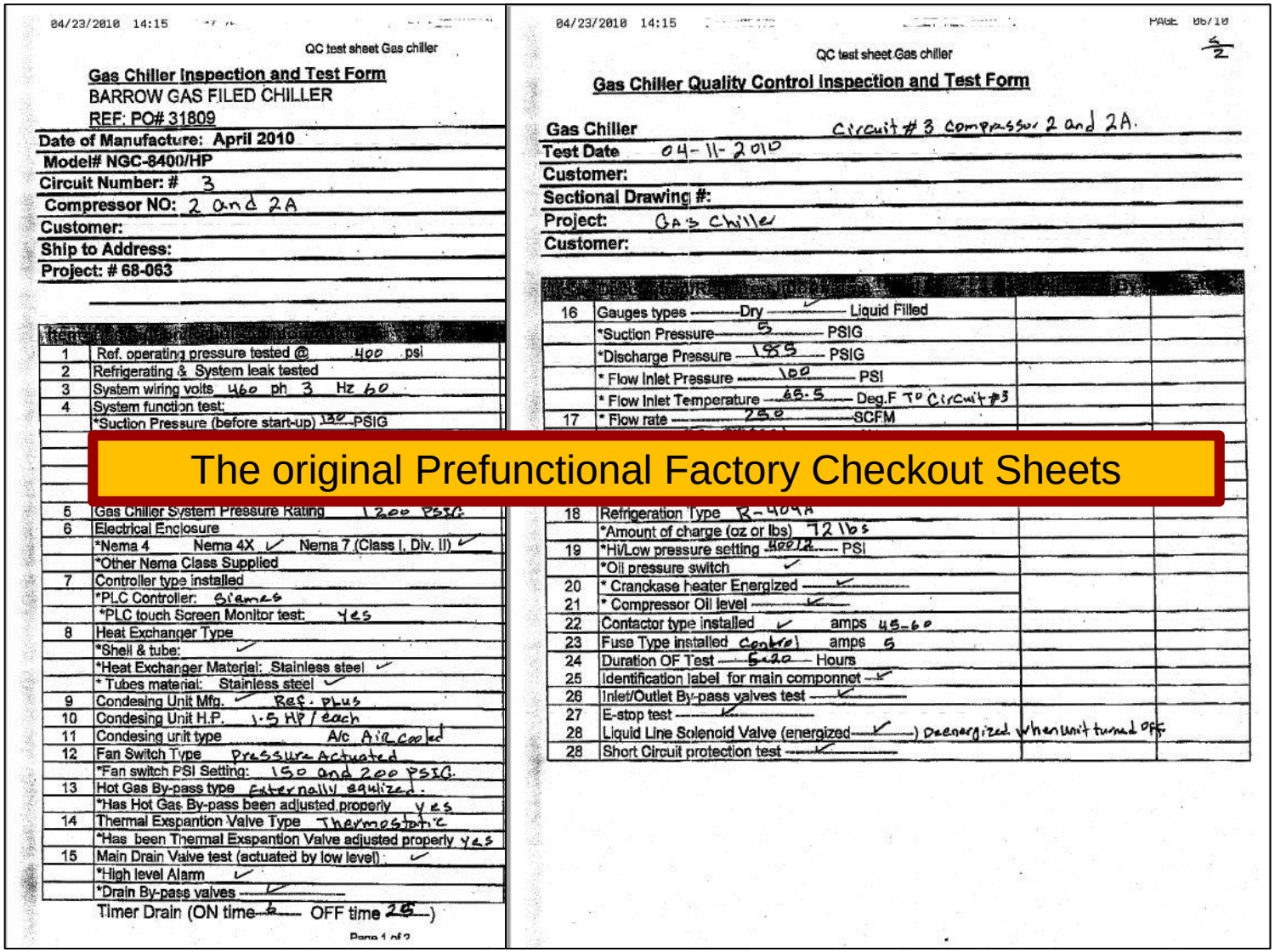
ReCommissioning an Industrial Gas Chiller

Initial Commissioning

Prefunctional

- Factory witness testing incomplete
- Manufacturer factory checkout report
- No Prefunctional examination recorded

ReCommissioning an Industrial Gas Chiller



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QC test sheet Gas chiller

Gas Chiller Inspection and Test Form

BARROW GAS FILED CHILLER

REF: PO# 31809

Date of Manufacture: April 2010

Model# NGC-8400/HP

Circuit Number: # 3

Compressor NO: 2 and 2A

Customer:

Ship to Address:

Project: # 68-063

1	Ref. operating pressure tested @ 400 psi	
2	Refrigerating & System leak tested	
3	System wiring volts 460 ph 3 Hz 60	
4	System function test:	
	*Suction Pressure (before start-up) 130 PSIG	
5	Gas Chiller System Pressure Rating 1200 PSIG	
6	Electrical Enclosure	
	*Nema 4 Nema 4X ✓ Nema 7 (Class I, Div. II) ✓	
	*Other Nema Class Supplied	
7	Controller type installed	
	*PLC Controller: Siemens	
	*PLC touch Screen Monitor test: Yes	
8	Heat Exchanger Type	
	*Shell & tube: ✓	
	*Heat Exchanger Material: Stainless steel ✓	
	* Tubes material: Stainless steel ✓	
9	Condesing Unit Mfg. ✓ Ref. plus	
10	Condesing Unit H.P. 1.5 HP / each	
11	Condesing unit type A/c Air Cooled	
12	Fan Switch Type Pressure Actuated	
	*Fan switch PSI Setting: 150 and 200 PSIG	
13	Hot Gas By-pass type Externally equlized.	
	*Has Hot Gas By-pass been adjusted properly Yes	
14	Thermal Exspantion Valve Type Thermostatic	
	*Has been Thermal Exspantion Valve adjusted properly Yes	
15	Main Drain Valve test (actuated by low level) ✓	
	*High level Alarm ✓	
	*Drain By-pass valves ✓	

Timer Drain (ON time 2 OFF time 25)

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5/2

QC test sheet Gas chiller

Gas Chiller Quality Control Inspection and Test Form

Gas Chiller Circuit # 3 Compressor 2 and 2A.

Test Date 04-11-2010

Customer:

Sectional Drawing #:

Project: GAS Chiller

Customer:

16	Gauges types ——Dry ✓—— Liquid Filled	
	*Suction Pressure 5 PSIG	
	*Discharge Pressure 185 PSIG	
	* Flow Inlet Pressure 100 PSI	
	* Flow Inlet Temperature 65.5 Deg.F To Circuit #3	
17	* Flow rate 250 SCFM	
18	Refrigeration Type R-404A	
	*Amount of charge (oz or lbs) 72 lbs	
19	*Hi/Low pressure setting 400/2 PSI	
	*Oil pressure switch ✓	
20	* Crankcase heater Energized ✓	
21	* Compressor Oil level ✓	
22	Contactor type installed ✓ amps 45-60	
23	Fuse Type installed Centre) amps 5	
24	Duration OF Test 5-20 Hours	
25	Identification label for main componnet ✓	
26	Inlet/Outlet By-pass valves test ✓	
27	E-stop test ✓	
28	Liquid Line Solenoid Valve (energized ✓) Deenergized when unit turned OFF	
28	Short Circuit protection test ✓	

The original Prefunctional Factory Checkout Sheets

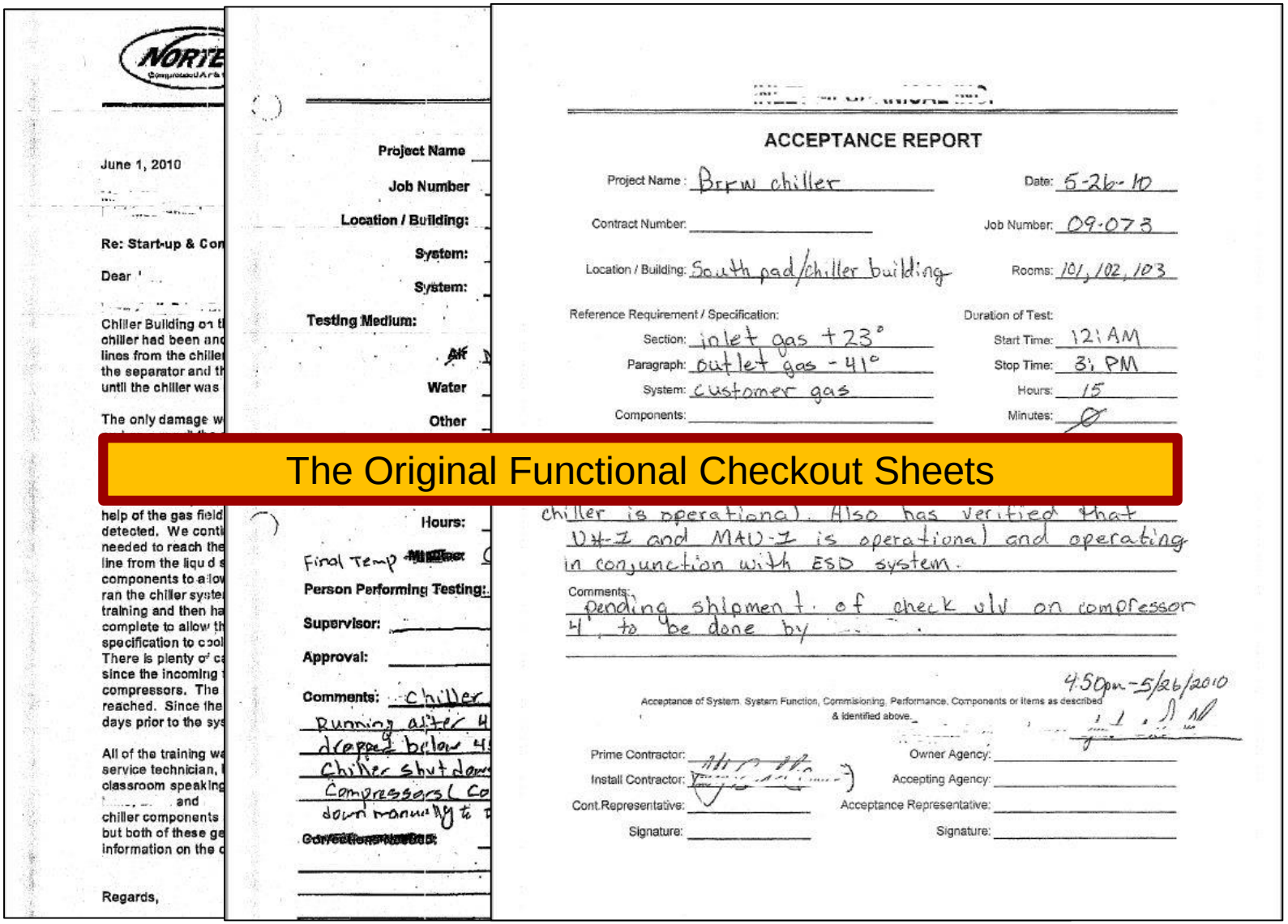
ReCommissioning an Industrial Gas Chiller

Initial Commissioning

Functional Testing

- Better described as a “Startup”
- Short runtime
- Minimal performance benchmarking
- Brief / poor records

ReCommissioning an Industrial Gas Chiller



June 1, 2010

Re: Start-up & Con

Dear

Chiller Building on t
chiller had been and
lines from the chille
the separator and th
until the chiller was

The only damage w

help of the gas field
detected. We conti
needed to reach the
line from the liqu d s
components to allow
ran the chiller syste
training and then ha
complete to allow th
specification to cool
There is plenty of ca
since the incoming
compressors. The
reached. Since the
days prior to the sys

All of the training wa
service technician,
classroom speaking
and
chiller components
but both of these ge
information on the c

Regards,

Project Name
Job Number
Location / Building:
System:
System:
Testing Medium:
Air
Water
Other

Hours:
Final Temp
Person Performing Testing:
Supervisor:
Approval:
Comments: Chiller
Running after 4
dropped below 4
Chiller shut down
Compressors (Co
down manually t
Corrections Needed:

ACCEPTANCE REPORT

Project Name: Brew chiller — Date: 5-26-10

Contract Number: — Job Number: 09-073

Location / Building: South pad/chiller building — Rooms: 101, 102, 103

Reference Requirement / Specification:
Section: inlet gas +23°
Paragraph: outlet gas -41°
System: customer gas
Components:

Duration of Test:
Start Time: 12 AM
Stop Time: 3 PM
Hours: 15
Minutes: 0

chiller is operational. Also has verified that UH-1 and MAU-1 is operational and operating in conjunction with ESD system.

Comments: pending shipment of check vlv on compressor 4 to be done by

4:50pm-5/26/2010

Acceptance of System. System Function, Commissioning, Performance, Components or Items as described & identified above.

Prime Contractor:
Install Contractor:
Cont.Representative:
Signature:

Owner Agency:
Accepting Agency:
Acceptance Representative:
Signature:

The Original Functional Checkout Sheets

ReCommissioning an Industrial Gas Chiller

The Process: ReCommissioning

Cx Plan

- Combination of Scoping, OPR, and Process
- Scoping

ReCommissioning an Industrial Gas Chiller

The ReCommissioning Process:

Cx Plan

- Scoping
  - Major refrigeration upgrades
  - Complete PLC replacement

ReCommissioning an Industrial Gas Chiller

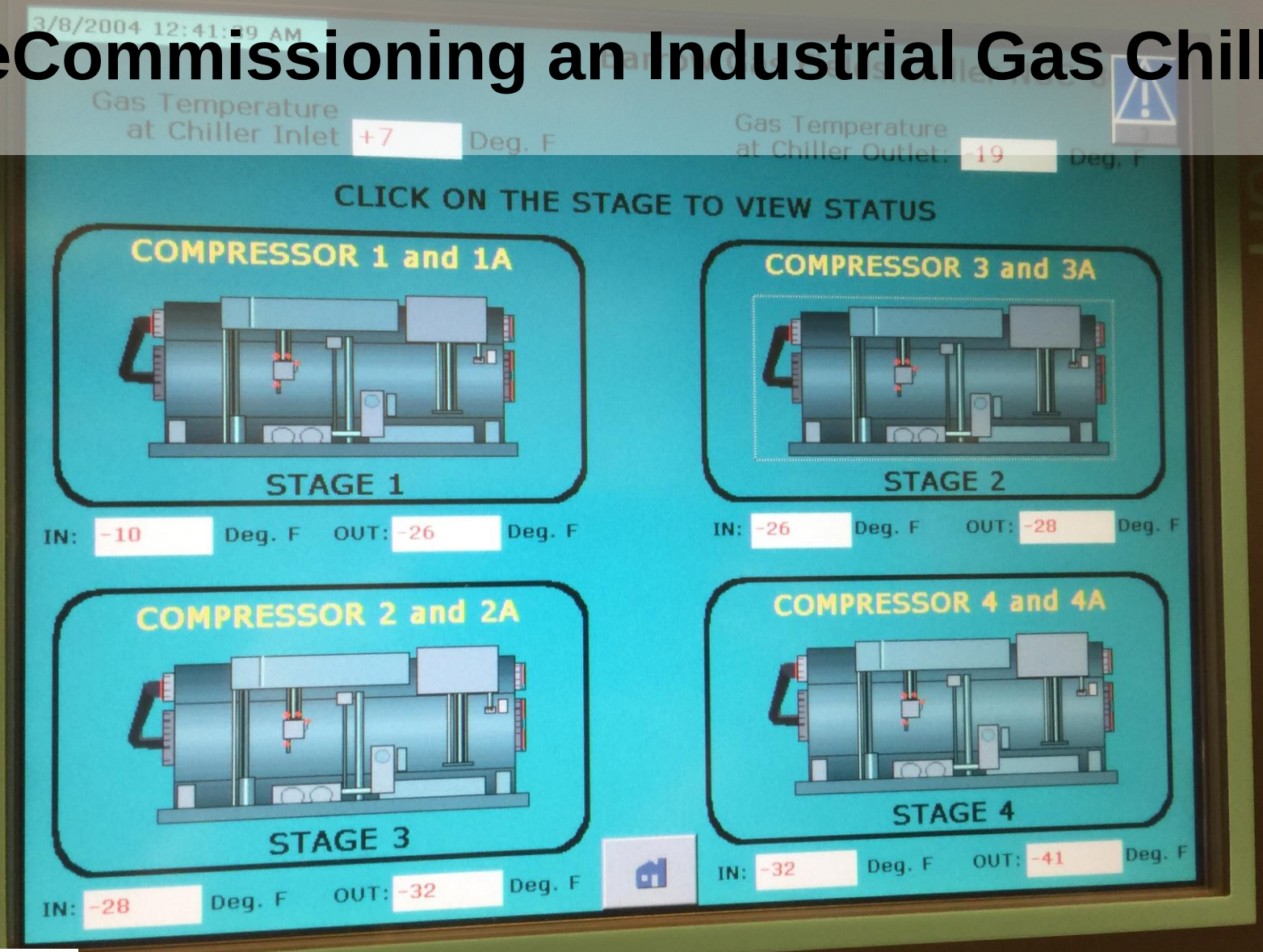
The Process: ReCommissioning

Cx Plan

Combination of Scoping, OPR, and Process

- Scoping
  - Major refrigeration upgrades
  - Complete PLC Replacement
  - CxA to represent Owner in RFPs
  - Develop RFPs & evaluate proposals from qualified contractors

ReCommissioning an Industrial Gas Chiller



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ReCommissioning an Industrial Gas Chiller

ReCommissioning an Industrial Gas Chiller

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CxEnergy 2018

CONTINUING EDUCATION 35 AIA

ReCommissioning an Industrial Gas Chiller

The Process: ReCommissioning

Cx Plan

- Combination of Scoping, OPR, and Process
- Process
  - Statement of 5 W's and 1 H

ReCommissioning an Industrial Gas Chiller

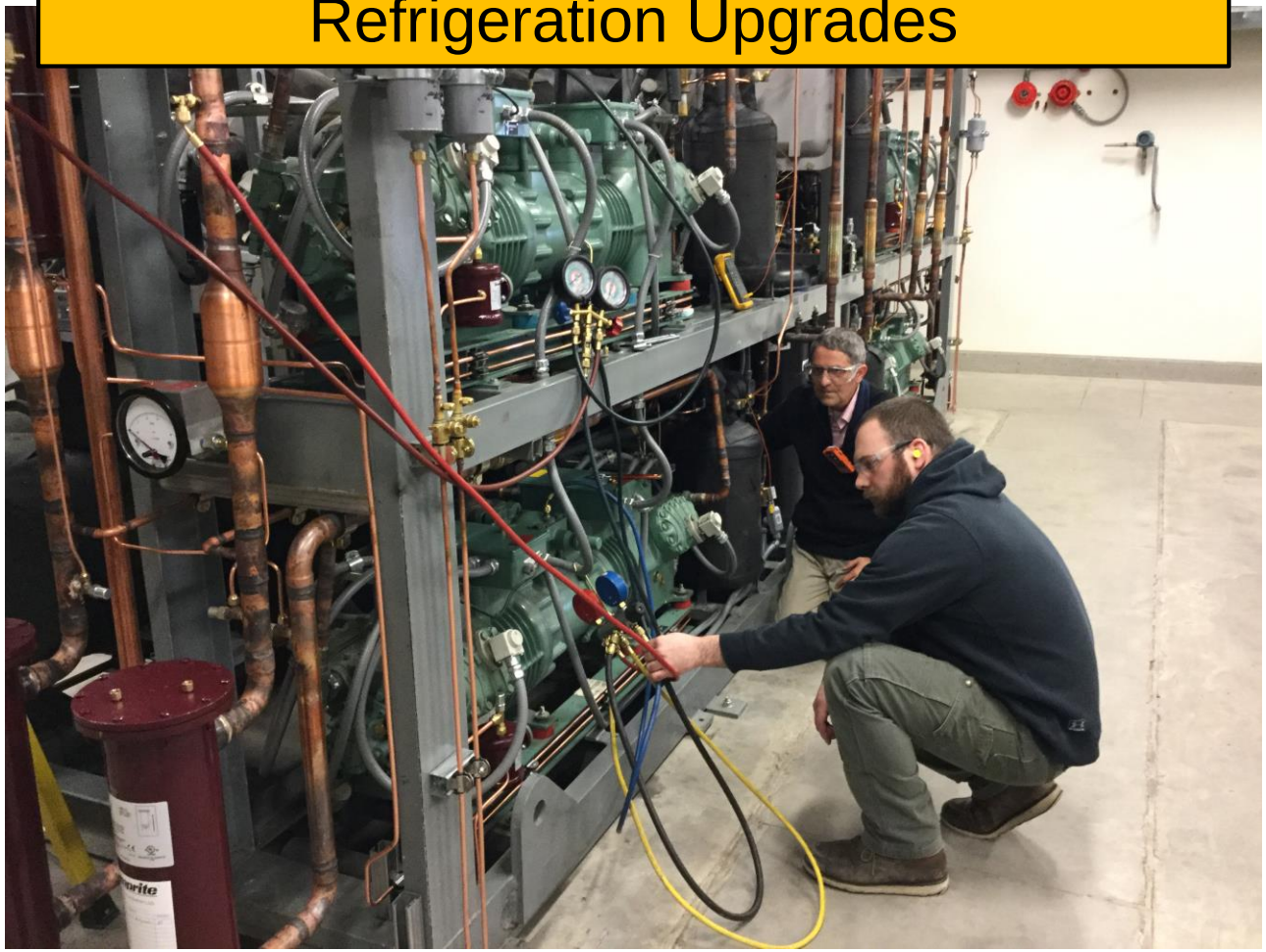
The Process: ReCommissioning

Cx Plan

- Combination of Scoping, OPR, and Process
- Process
  - Statement of 5 W's and 1 H
  - Issue Prefunctional checksheets

ReCommissioning an Industrial Gas Chiller

Refrigeration Upgrades



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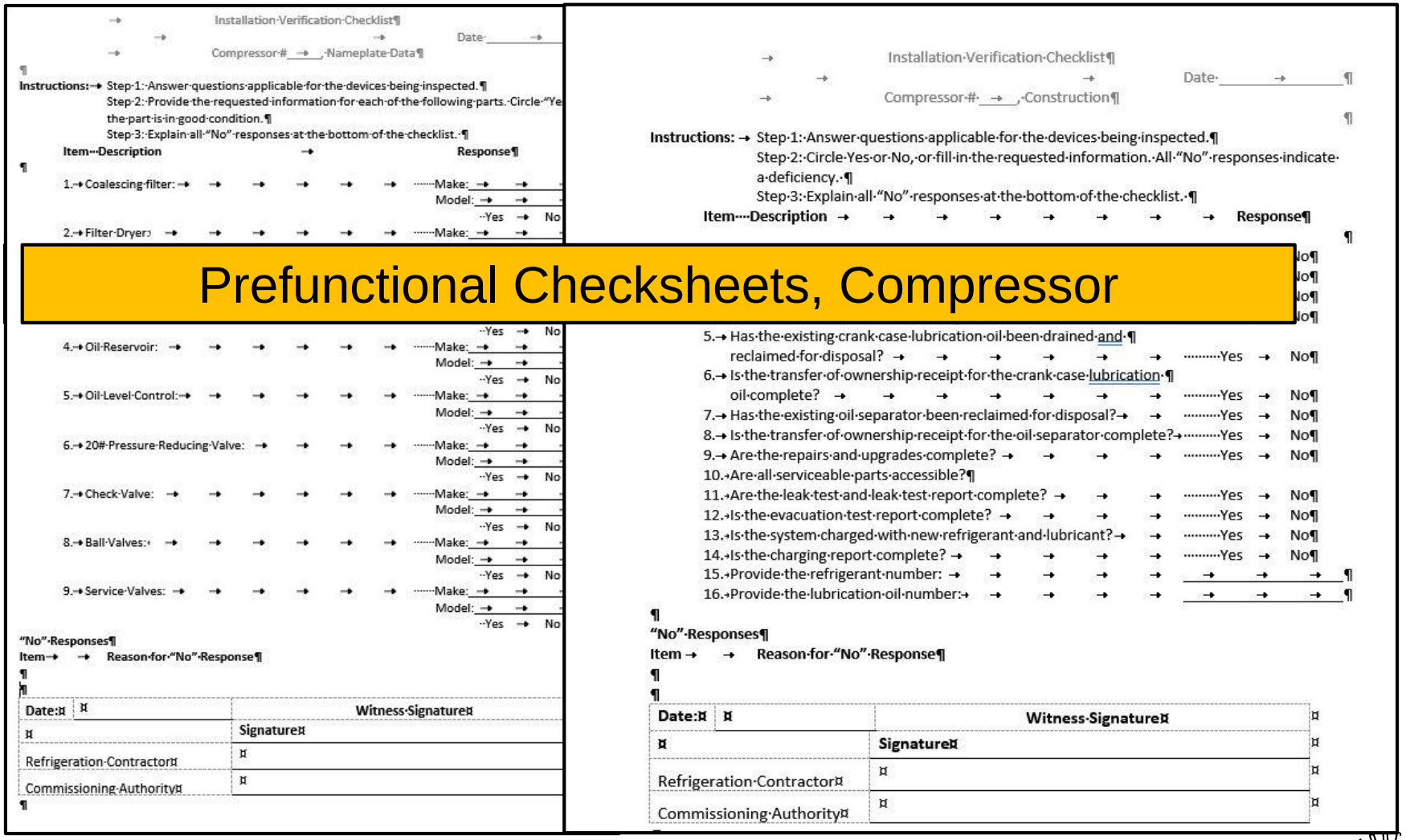


Installation Verification Checklist

Date

Compressor #, Nameplate Data

Instructions: Step 1: Answer questions applicable for the devices being inspected.
Step 2: Provide the requested information for each of the following parts. Circle "Ye
the part is in good condition.
Step 3: Explain all "No" responses at the bottom of the checklist.

Item Description Response

1. Coalescing filter: Make: Model: Yes No
2. Filter Dryer: Make: Yes No
4. Oil Reservoir: Make: Model: Yes No
5. Oil Level Control: Make: Model: Yes No
6. 20# Pressure Reducing Valve: Make: Model: Yes No
7. Check Valve: Make: Model: Yes No
8. Ball Valves: Make: Model: Yes No
9. Service Valves: Make: Model: Yes No

"No" Responses
Item Reason for "No" Response

Date:	Witness Signature
	Signature
Refrigeration Contractor	
Commissioning Authority	

Installation Verification Checklist

Date

Compressor #, Construction

Instructions: Step 1: Answer questions applicable for the devices being inspected.
Step 2: Circle Yes or No, or fill in the requested information. All "No" responses indicate a deficiency.
Step 3: Explain all "No" responses at the bottom of the checklist.

Item Description Response

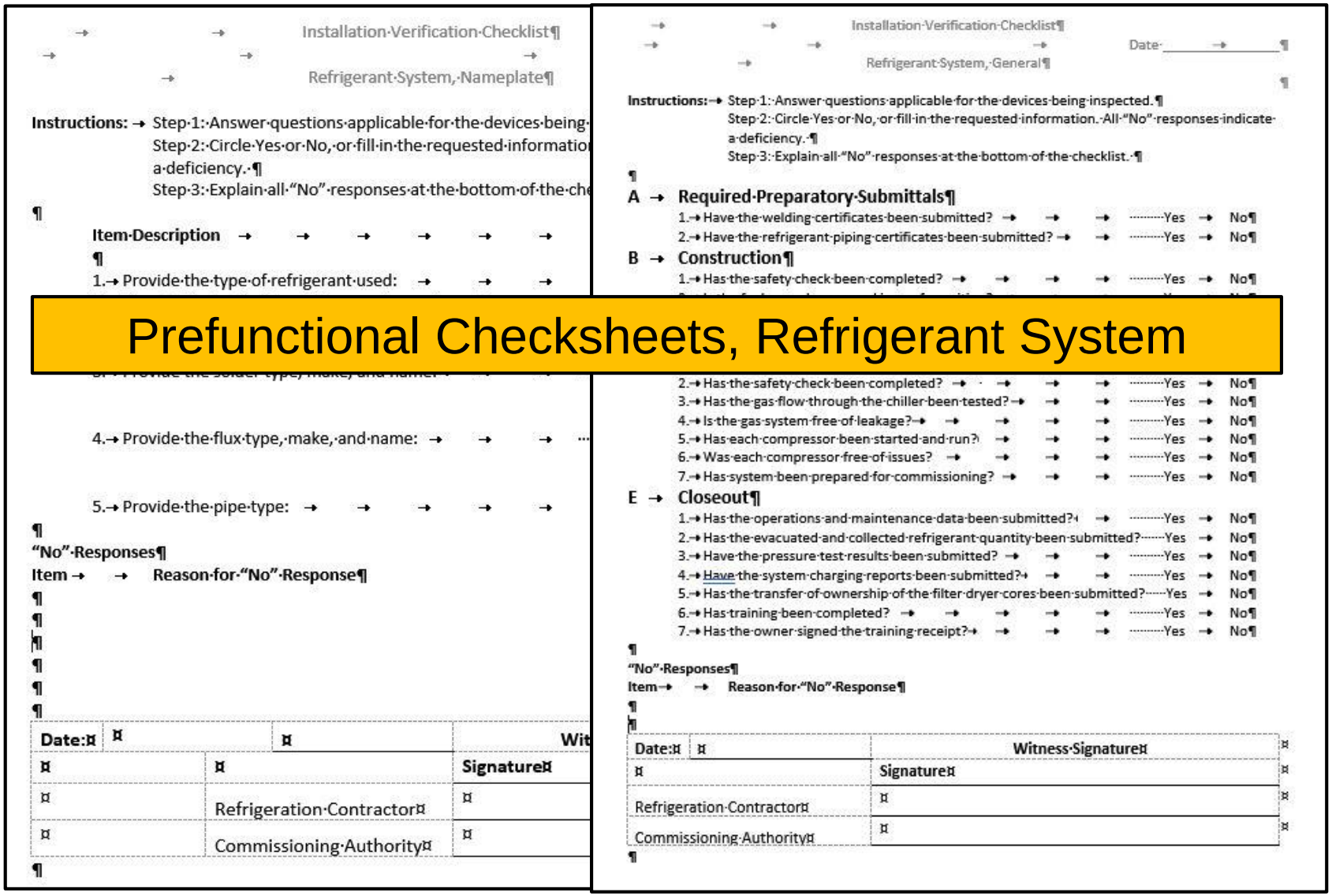
5. Has the existing crank case lubrication oil been drained and reclaimed for disposal? Yes No
6. Is the transfer of ownership receipt for the crank case lubrication oil complete? Yes No
7. Has the existing oil separator been reclaimed for disposal? Yes No
8. Is the transfer of ownership receipt for the oil separator complete? Yes No
9. Are the repairs and upgrades complete? Yes No
10. Are all serviceable parts accessible?
11. Are the leak test and leak test report complete? Yes No
12. Is the evacuation test report complete? Yes No
13. Is the system charged with new refrigerant and lubricant? Yes No
14. Is the charging report complete? Yes No
15. Provide the refrigerant number:
16. Provide the lubrication oil number:

"No" Responses
Item Reason for "No" Response

Date:	Witness Signature
	Signature
Refrigeration Contractor	
Commissioning Authority	

Prefunctional Checksheets, Compressor

ReCommissioning an Industrial Gas Chiller



Installation Verification Checklist

Refrigerant System, Nameplate

Instructions: Step 1: Answer questions applicable for the devices being
Step 2: Circle Yes or No, or fill in the requested information
a deficiency.
Step 3: Explain all "No" responses at the bottom of the ch

Item Description

1. Provide the type of refrigerant used:

4. Provide the flux type, make, and name:

5. Provide the pipe type:

"No" Responses

Item Reason for "No" Response

Date:		Wit
		Signature
	Refrigeration Contractor	
	Commissioning Authority	

Installation Verification Checklist

Date: _____

Refrigerant System, General

Instructions: Step 1: Answer questions applicable for the devices being inspected.
Step 2: Circle Yes or No, or fill in the requested information. All "No" responses indicate a deficiency.
Step 3: Explain all "No" responses at the bottom of the checklist.

A Required Preparatory Submittals
1. Have the welding certificates been submitted? Yes No
2. Have the refrigerant piping certificates been submitted? Yes No

B Construction
1. Has the safety check been completed? Yes No
2. Has the safety check been completed? Yes No
3. Has the gas flow through the chiller been tested? Yes No
4. Is the gas system free of leakage? Yes No
5. Has each compressor been started and run? Yes No
6. Was each compressor free of issues? Yes No
7. Has system been prepared for commissioning? Yes No

E Closeout
1. Has the operations and maintenance data been submitted? Yes No
2. Has the evacuated and collected refrigerant quantity been submitted? Yes No
3. Have the pressure test results been submitted? Yes No
4. Have the system charging reports been submitted? Yes No
5. Has the transfer of ownership of the filter dryer cores been submitted? Yes No
6. Has training been completed? Yes No
7. Has the owner signed the training receipt? Yes No

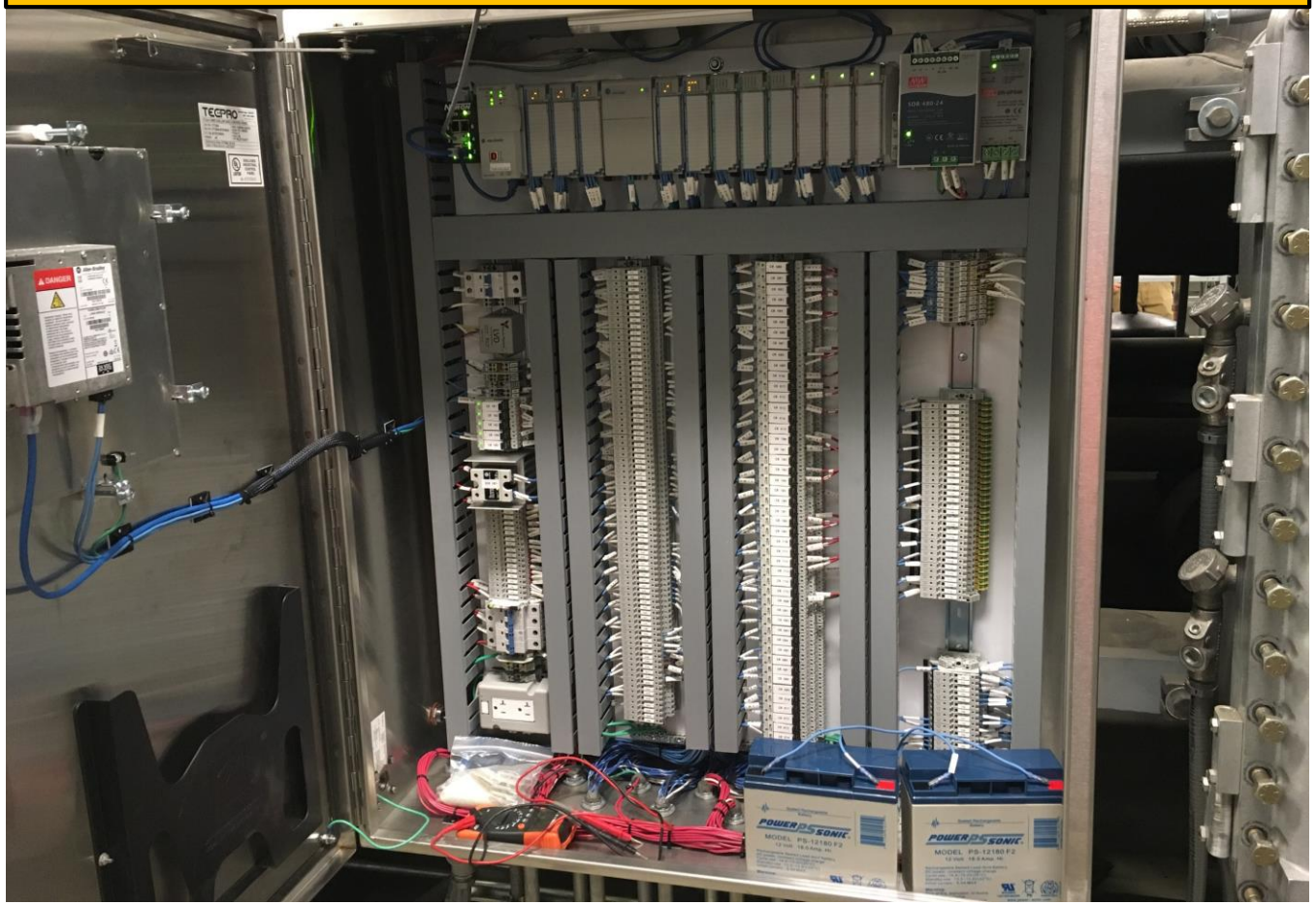
"No" Responses
Item Reason for "No" Response

Date:	Witness Signature
	Signature
Refrigeration Contractor	
Commissioning Authority	

Prefunctional Checksheets, Refrigerant System

ReCommissioning an Industrial Gas Chiller

Programmable Logic Controller Replacement



ReCommissioning an Industrial Gas Chiller

Class 1 Div 2, 500 PSI Oil Level Monitors

ReCommissioning an Industrial Gas Chiller

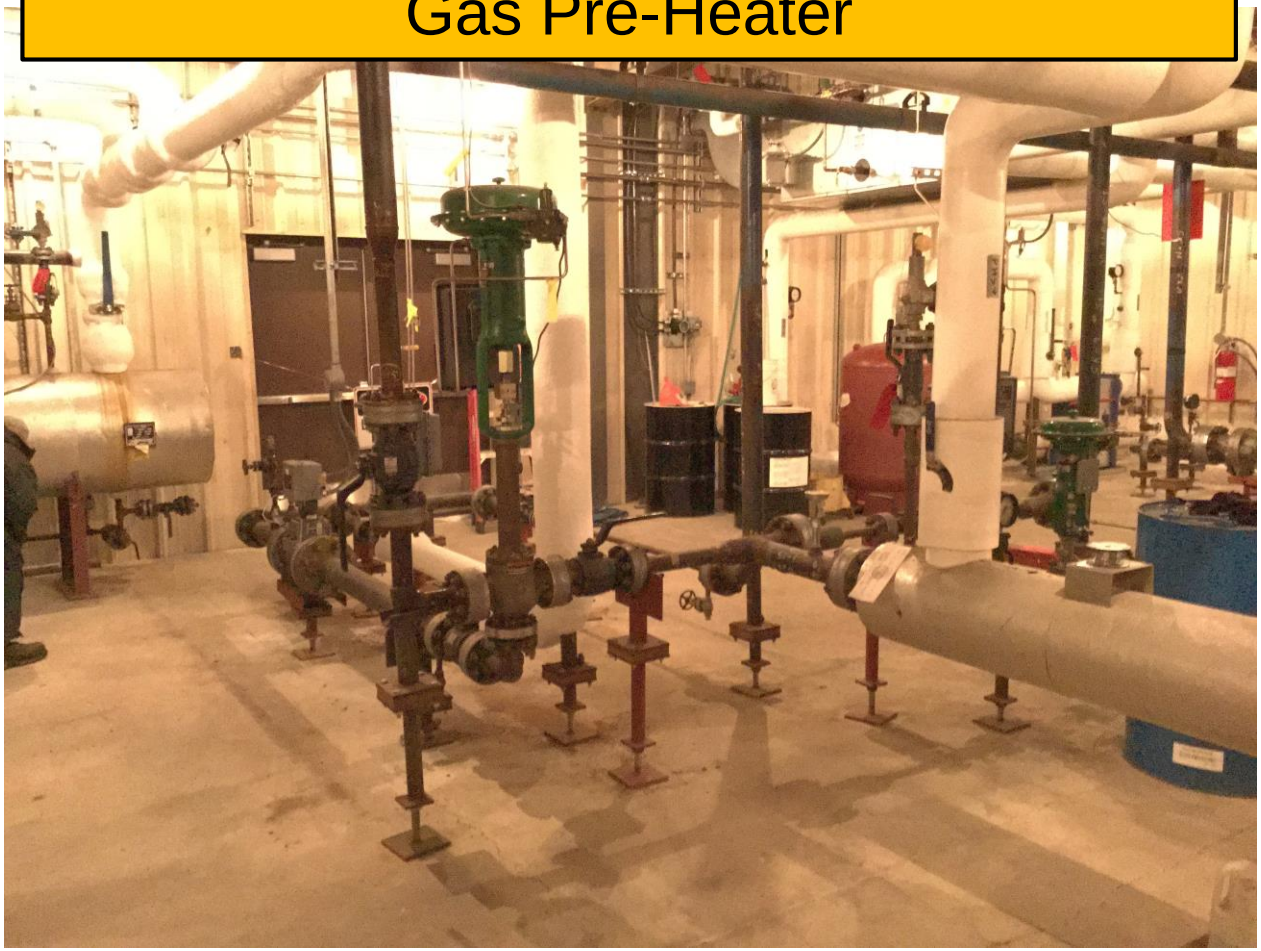
The Process: ReCommissioning

Cx Plan

- Combination of Scoping, OPR, and Process
- Process
  - Statement of 5 W's and 1 H
  - Issue Prefunctional checksheets
  - Issue Functional Performance Tests

ReCommissioning an Industrial Gas Chiller

Gas Pre-Heater



Functional Performance Test	North Slope Borough Natural Gas Chiller	Date

Demonstrate the following:

Communication with PLC
- Graphics complete and functional

Communication with Remote Workstation
- Graphics complete and functional

Chiller Operation
- Gas valve control
- Chiller start
- Chiller modulation
- Chiller setpoint control

Alarms
- Head pressure (high / Low)
- Low oil pressure
- Gas temperature
- Room 20 % LEL
- Room 40 % LEL
- Room 60 % LEL

Prepare the following tools and supplies:	
Refrigeration toolbox	

Associated Equipment Matrix

Item	Interlock	Normally Open or ON	Normally Closed or OFF
HVAC Supply	Normal Operation	Yes	
HVAC Supply	Safety Operation		Yes
HVAC Exhaust	Normal Operation		Yes
HVAC Exhaust	Safety Operation	Yes	
Chiller	Normal Operation	Yes	
Chiller	Safety Operation		Yes

Note: A HAZ OPS matrix must be completed prior to final testing of the new PLC

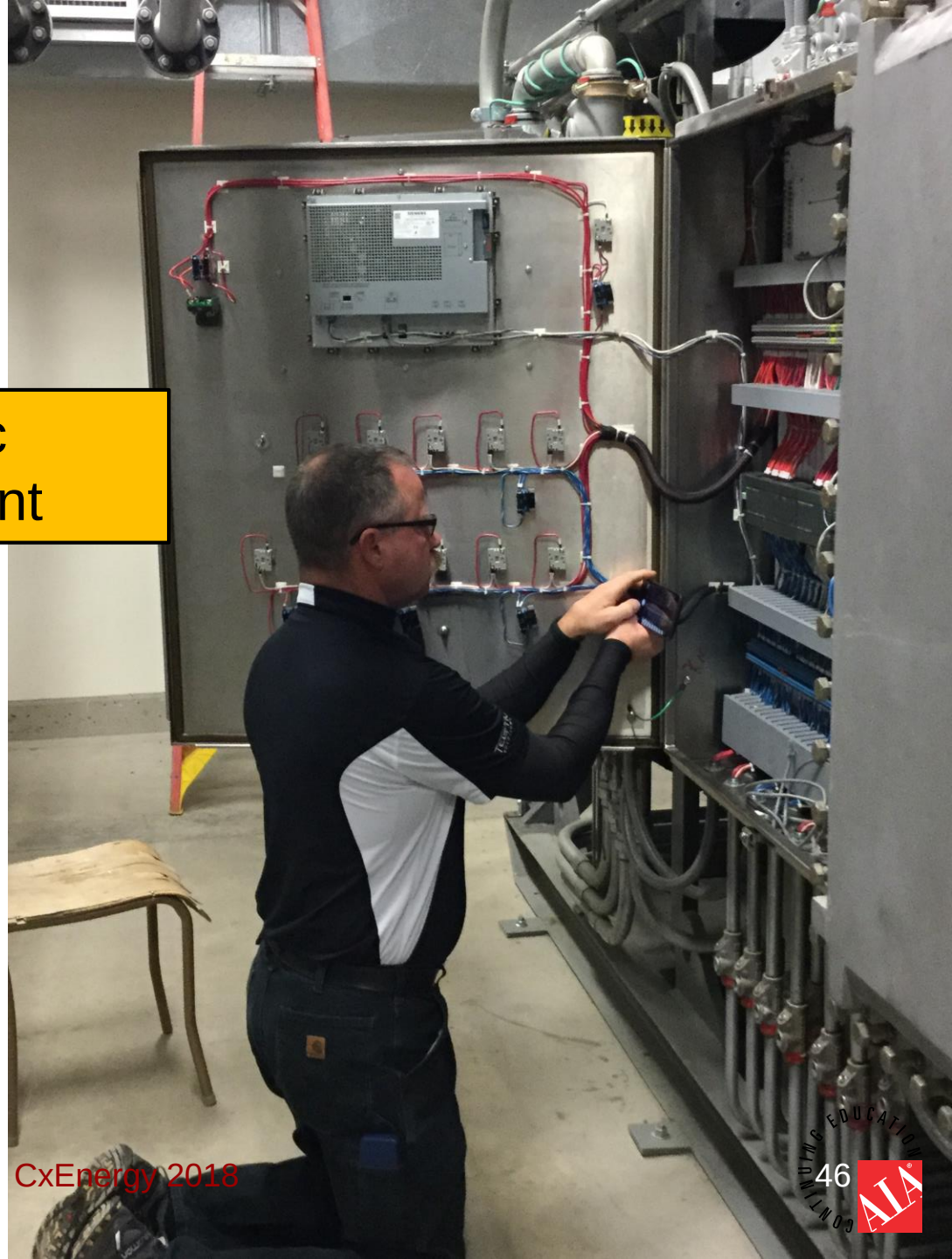
Functional Performance Test	North Slope Borough Natural Gas Chiller	Date

	Test	Expected Results	Result
1.	Verify facility is in safe mode.	Gas valve isolates chiller building from Primary Gas Handling Facility (PGHF)	Y/N
2.	Verify air cooled condensing unit (ACCU) is safe to operate	All snow and ice removed from ACCU and fans. Free air passage through coils and fans is available ACCU has been above 40°F for at least 24 hours	Y/N Y/N Y/N
3.	Verify chiller is safe to operate	Crankcase heaters have been on for at least 24 hours	Y/N
		Compressor #1	____PSI
		Suction pressure	____PSI
		Discharge Pressure	
		Compressor #2	____PSI
		Suction pressure	____PSI
		Discharge Pressure	
		Compressor #3	____PSI
		Suction pressure	____PSI
		Discharge Pressure	
		Compressor #4	____PSI
		Suction pressure	____PSI
		Discharge Pressure	
		Oil level is mid-point of sight glass	
		Compressor #1	
		Crankcase A	Y/N
		Crankcase B	Y/N
		Oil Reservoir	Y/N
		Compressor #2	
		Crankcase A	Y/N
		Crankcase B	Y/N
		Oil Reservoir	Y/N
		Compressor #3	
		Crankcase A	Y/N
		Crankcase B	Y/N
		Oil Reservoir	Y/N
		Compressor #4	
		Crankcase A	Y/N
		Crankcase B	Y/N
		Oil Reservoir	Y/N

Functional Performance Tests

ReCommissioning an Industrial Gas Chiller

Programmable Logic Controller Replacement



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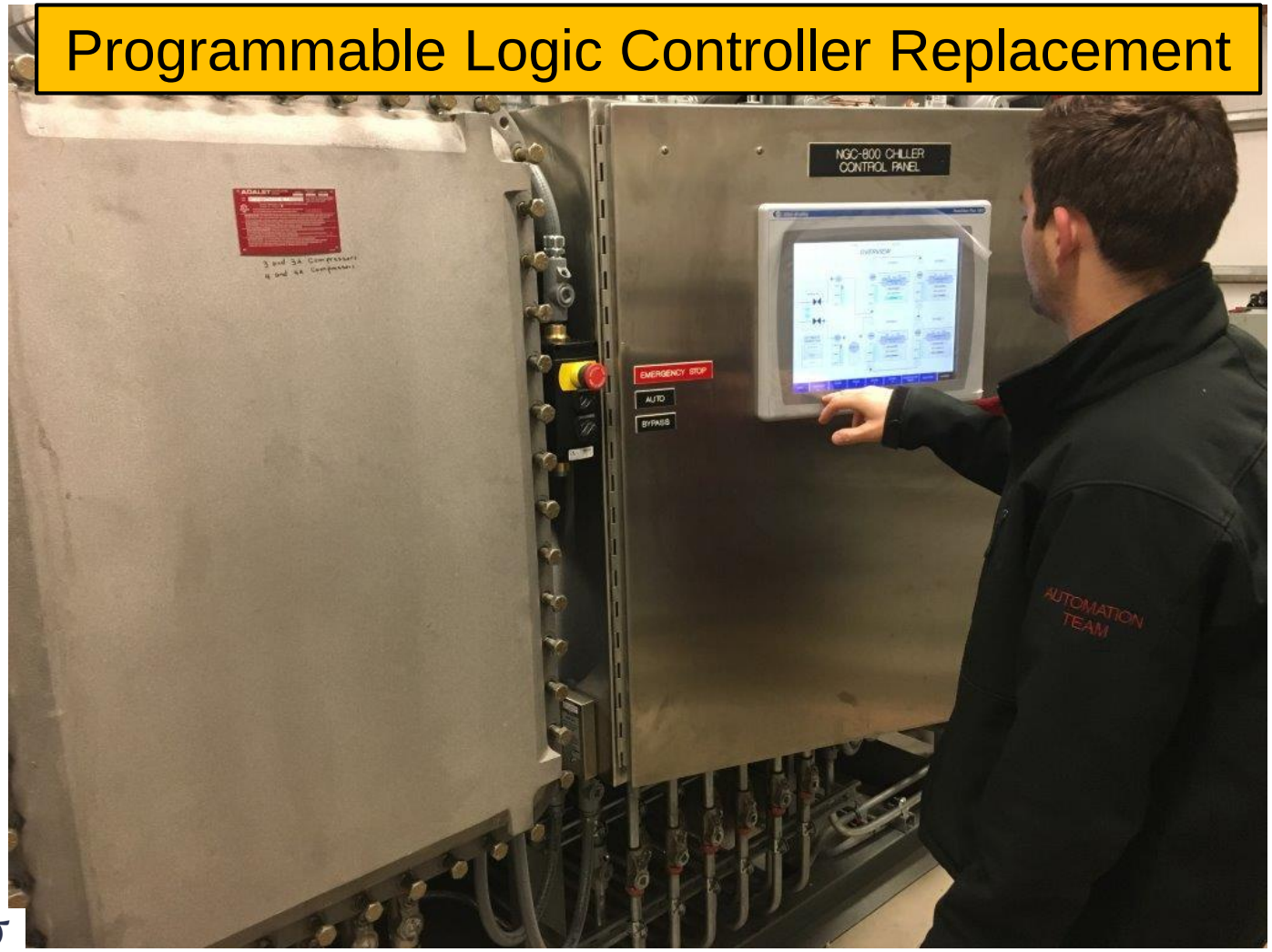
ReCommissioning an Industrial Gas Chiller



Functional Performance Test	North Slope Borough Natural Gas Chiller	Date

	Test	Expected Results	Result
15.	Add heat to gas in the PGHF. Raise entering gas temperature by 10°F from initial entering condition. State conditions of gas heater and valve. _____ _____ _____	Entering gas temperature Entering gas flow rate Chiller stage 4 starts # heads running in stage 4 Gas discharge temperature Chiller stage 3 starts # heads running in stage 3 Gas discharge temperature Chiller stage 2 starts # heads running in stage 2 Gas discharge temperature Chiller stage 1 starts	_____°F _____CFH Y/N _____ _____ Y/N _____ _____ Y/N _____ _____ Y/N
16.	Operate chiller for 30 minutes at this condition If all chiller stages are operating with two compressor head loaded, skip next line and proceed to line 27	Chiller operation stable Gas discharge temp is stable All oil levels are stable in mid-point of sight glasses (12)	Y/N Y/N Y/N
17.	Add heat to gas in the PGHF. Raise entering gas temperature by 10°F from previous entering condition. State conditions of gas heater and valve. _____ _____ _____ _____ _____	Entering gas temperature Entering gas flow rate Chiller stage 4 starts # heads running in stage 4 Gas discharge temperature Chiller stage 3 starts # heads running in stage 3 Gas discharge temperature Chiller stage 2 starts # heads running in stage 2 Gas discharge temperature Chiller stage 1 starts # heads running in stage 1 Gas discharge temperature Gas setpoint -40°F is achieved	_____°F _____CFH Y/N _____ _____ Y/N _____ _____ Y/N _____ _____ Y/N

Functional Performance Tests

Functional Performance Test	North Slope Borough Natural Gas Chiller	Date

Complete the appropriate table below

Performance Benchmarking:

Elevate natural gas (NG) temperature at the heat exchanger (HX) in the Gas Control Building.

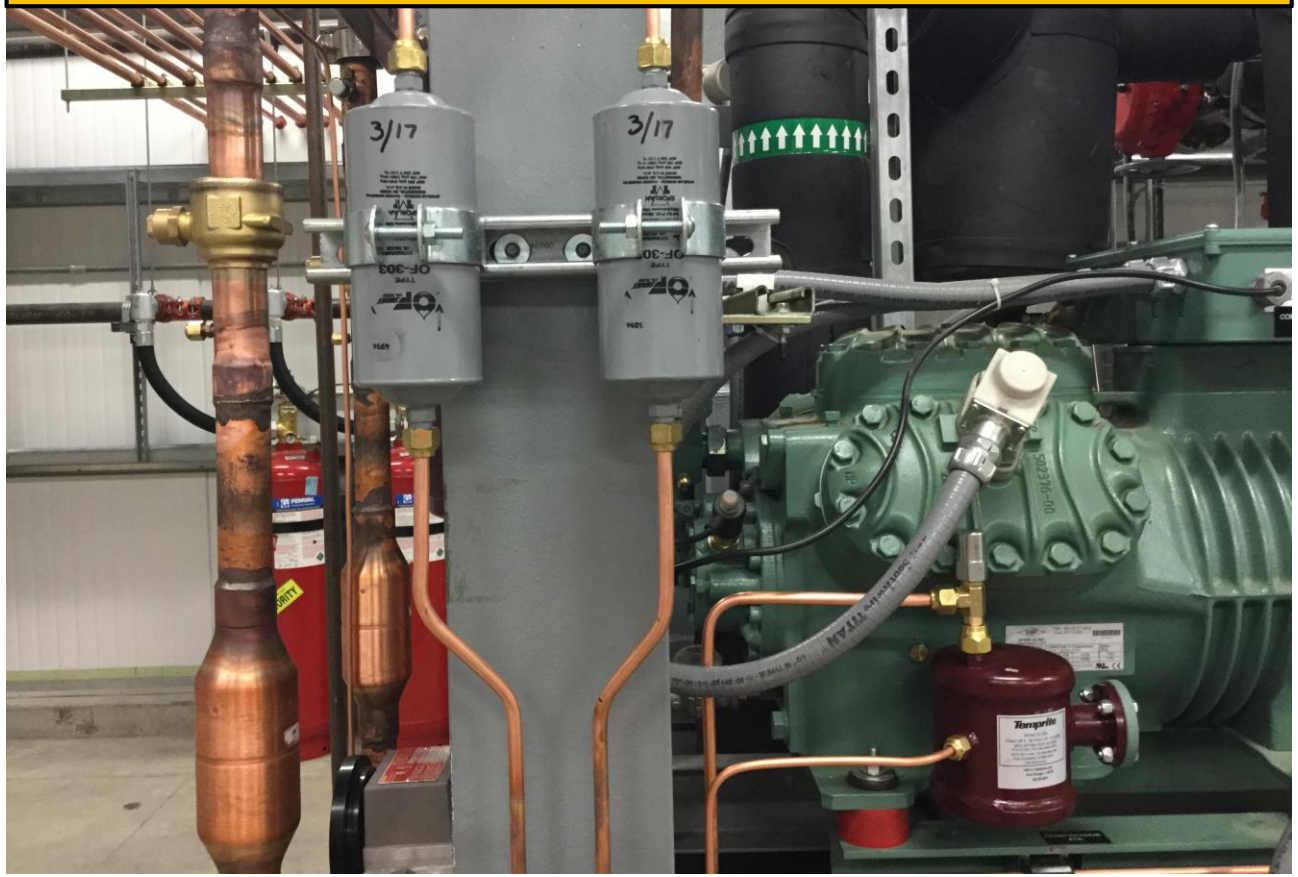
Gas Control Building		
NG Temperature leaving HX	°F	
NG Flow Rate	CFH	
Chiller Free-cooler HX		
NG Entering Temperature	°F	
NG Leaving Temperature	°F	
Chiller Stage 1		
Voltage A-B	Voltage A-C	Voltage B-C
Current A	Current B	Current C
NG Entering Temperature	°F	
NG Leaving Temperature	°F	
Chiller Stage 3		
Voltage A-B	Voltage A-C	Voltage B-C
Current A	Current B	Current C
NG Entering Temperature	°F	
NG Leaving Temperature	°F	
Chiller Stage 4		
Voltage A-B	Voltage A-C	Voltage B-C
Current A	Current B	Current C
NG Entering Temperature	°F	
NG Leaving Temperature	°F	
Condensate Observation		
Time (length of test)	HH:MM	
Total Condensate	Lb.	

ReCommissioning an Industrial Gas Chiller

Oil Management Systems

ReCommissioning an Industrial Gas Chiller

Oil Management Systems



ReCommissioning an Industrial Gas Chiller

The Process: ReCommissioning

Project Closeout

- Training
  - Develop content
  - Engage videographer
  - Schedule trainees

ReCommissioning an Industrial Gas Chiller

ReCommissioning an Industrial Gas Chiller

The Process: ReCommissioning

Project Closeout

- Training
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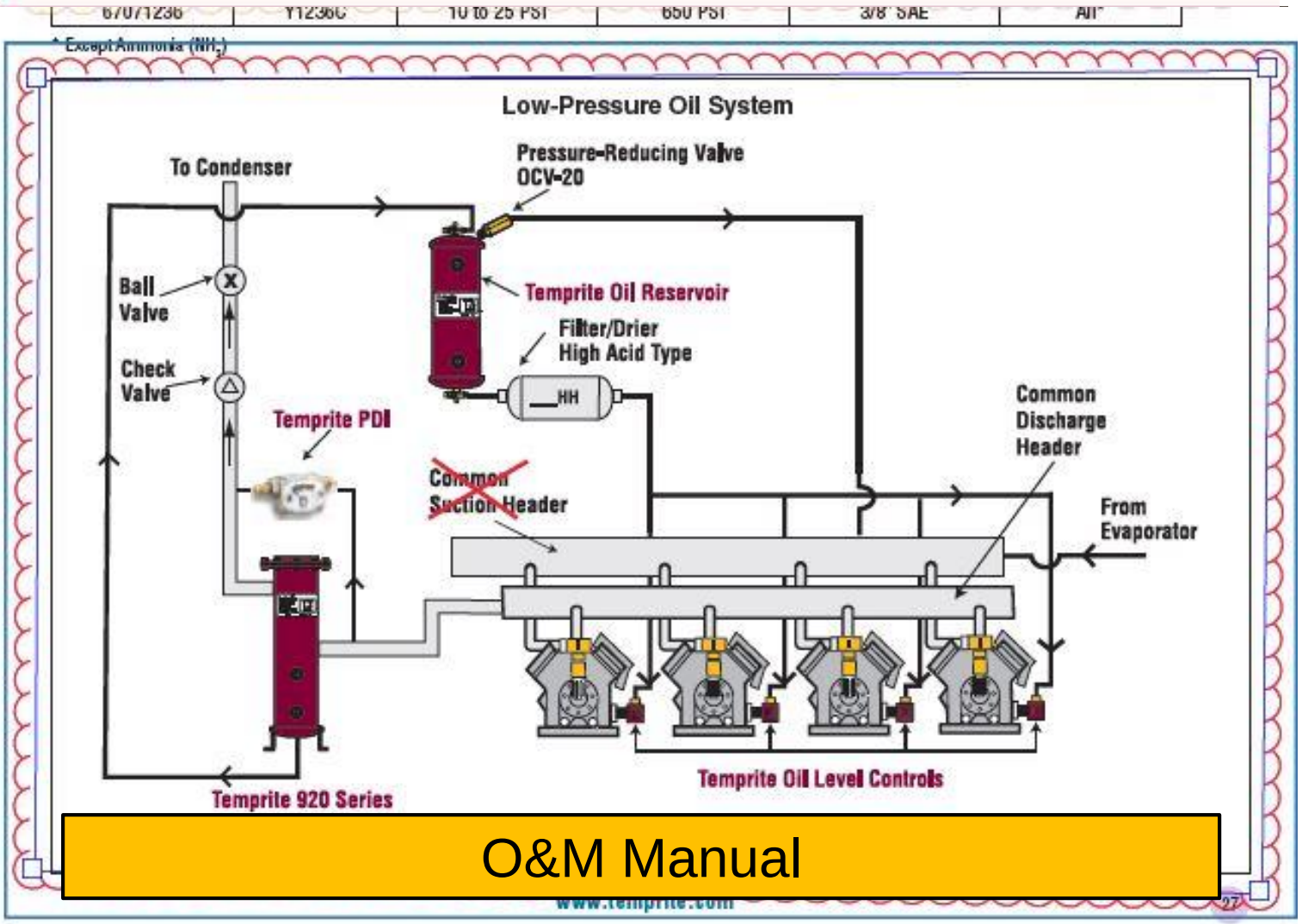
- O&M Manual


Except Ammonia (NH_3)
Low-Pressure Oil System
To Condenser
Pressure-Reducing Valve
OCV-20
Ball Valve
Check Valve
Temprite Oil Reservoir
Filter/Drier
High Acid Type
HH
Temprite PDI
Common Suction Header
Common Discharge Header
From Evaporator
Temprite 920 Series
Temprite Oil Level Controls
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O&M Manual

ReCommissioning an Industrial Gas Chiller

The Building Commissioning Process

- Equipment was examined
- Owner's Project Requirements were compiled
- Project specifications were developed
  - Plans and Specs
  - Testing, Training, and O&Ms

ReCommissioning an Industrial Gas Chiller

The Building Commissioning Process

- Owner was represented by qualified engineers during upgrades
- System underwent rigorous FCO over a wide operating range
- Project accepted based on verifiable criteria

ReCommissioning an Industrial Gas Chiller

The Building Commissioning Process

Job Complete!

ReCommissioning an Industrial Gas Chiller

Lessons Learned

- The *building* commissioning processes are adaptable to commissioning *any* project
- Get the Whole Story!!!
  - Work with the Owners to develop the OPR
- Owners can only expect thorough commissioning if they specify it

This concludes The American Institute of Architects Continuing Education Systems Course

ReCommissioning an Industrial Gas Chiller

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