Less is More: Flare Minimization During Cooldown

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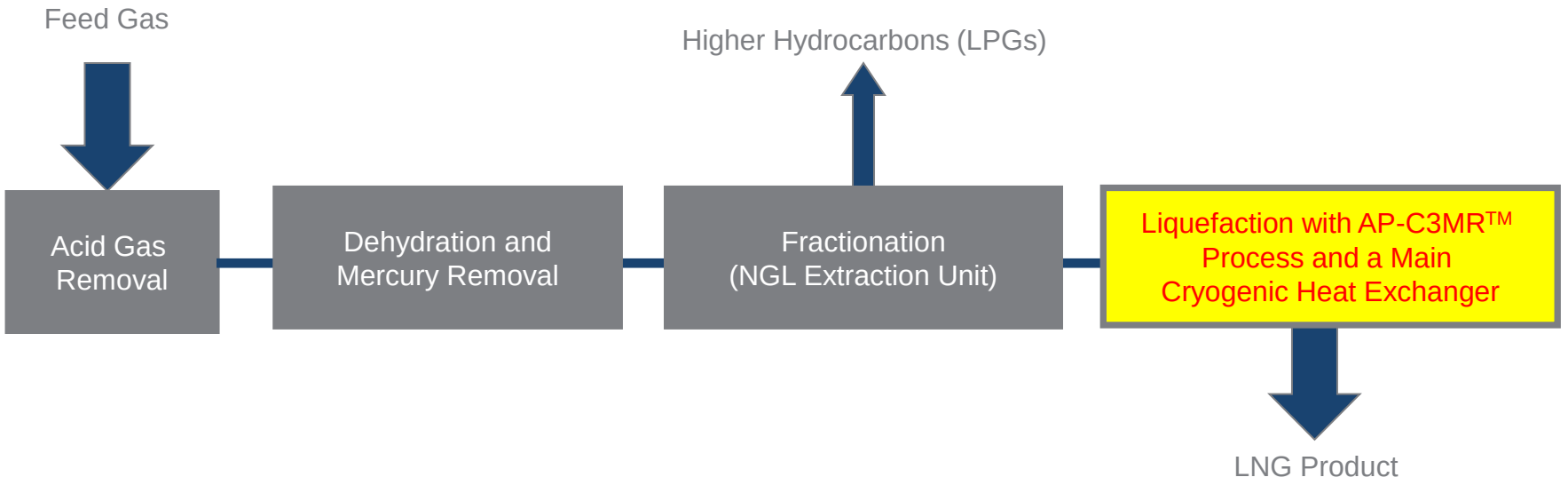
PRESENTED BY IGU gti iif iir

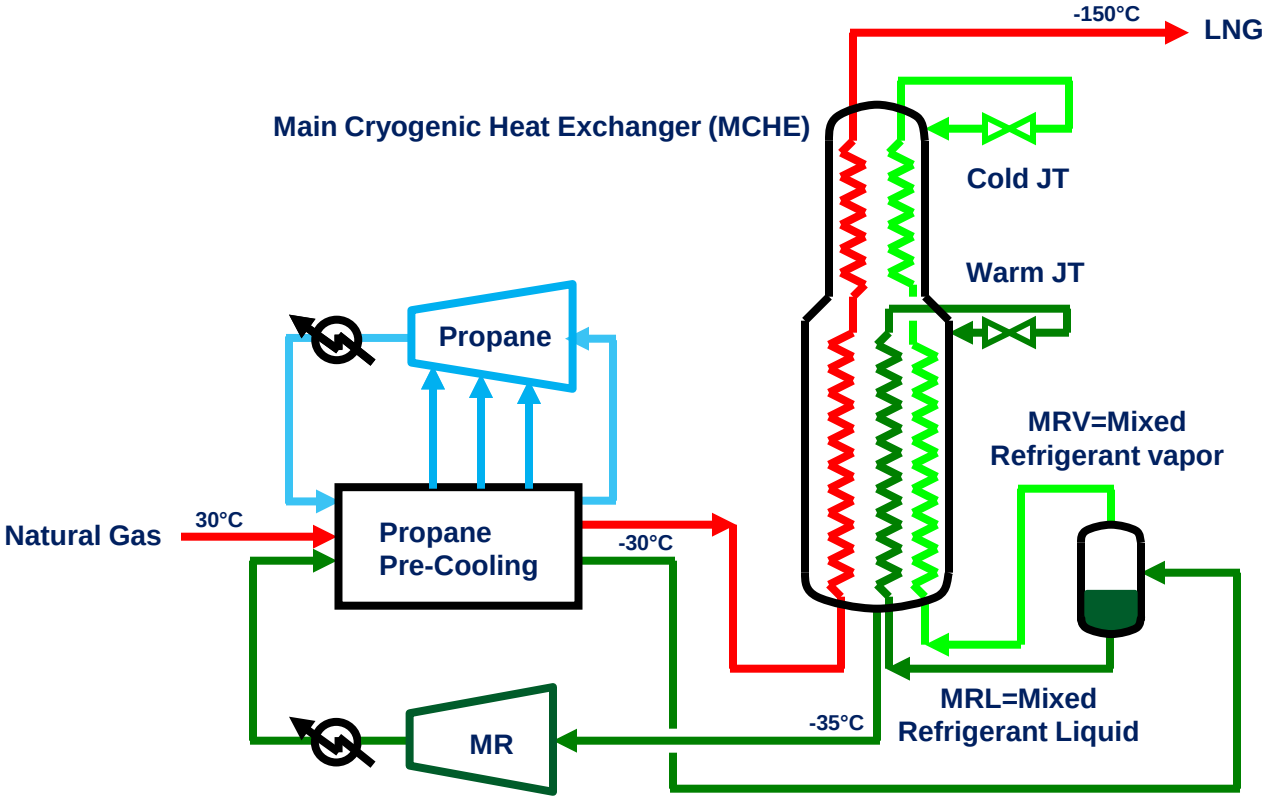
Agenda

- The AP-C3MR™ Liquefaction Process
- Steps to LNG Production
- Traditional Liquefaction Train Cooldown
- New Method: Reduced Flaring Cooldown
- The AP-Autocool™ Program
- LNG Recycle
- Summary

LNG Facility Overview



The AP-C3MR™ Process



Steps Towards First LNG Shipment

- Inert the system
- Defrost the equipment
- Introduce hydrocarbons
- Cooldown to LNG temperatures
- Adjust the operation
- Fill the tanks

Courtesy of Oman LNG

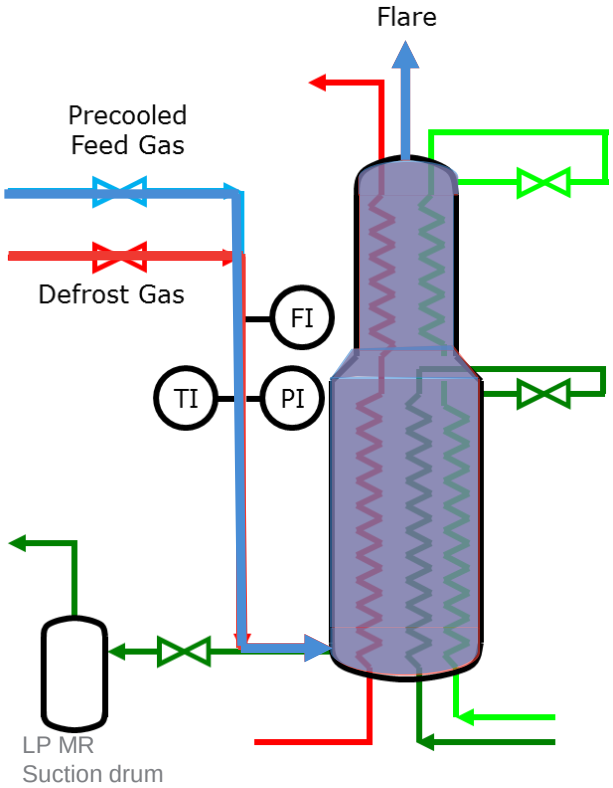
Traditional Cooldown Method

1. Precooldown from ambient to -30°C
2. Final cooldown from -30°C to -150°C

Traditional Precooldown Step

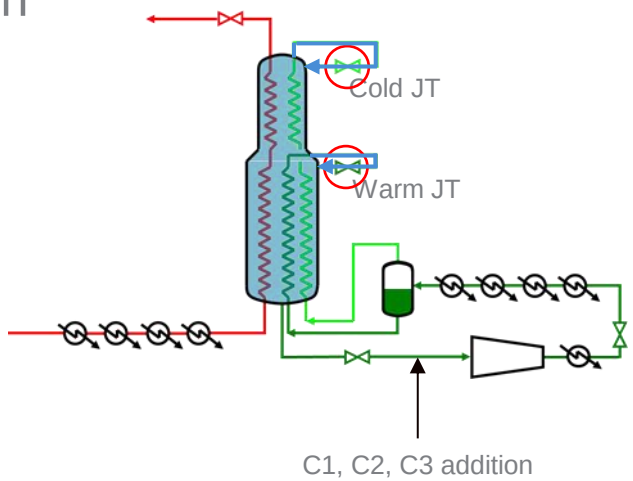
Purpose: cool the MCHE from ambient to propane temperatures to achieve uniform temperature profile and minimize thermal stresses.

- Blends defrost and feed gas
- Flows through the shell in the reverse direction and out to the flare
- Prepares the exchanger to accept cold feed and MR streams
- Typically takes ~12 hours



Traditional Final Cooldown Step

- Refrigerant flow started in the normal direction
- Cold JT valve opened first
- Warm JT valve opened shortly after
- Once the cooling slows, C1, C2, and C3 are added
- At the MR liquid transition point, cooling rate increases drastically and feed is added to control the cooldown rate
- N2 added to MR to achieve LNG temperatures



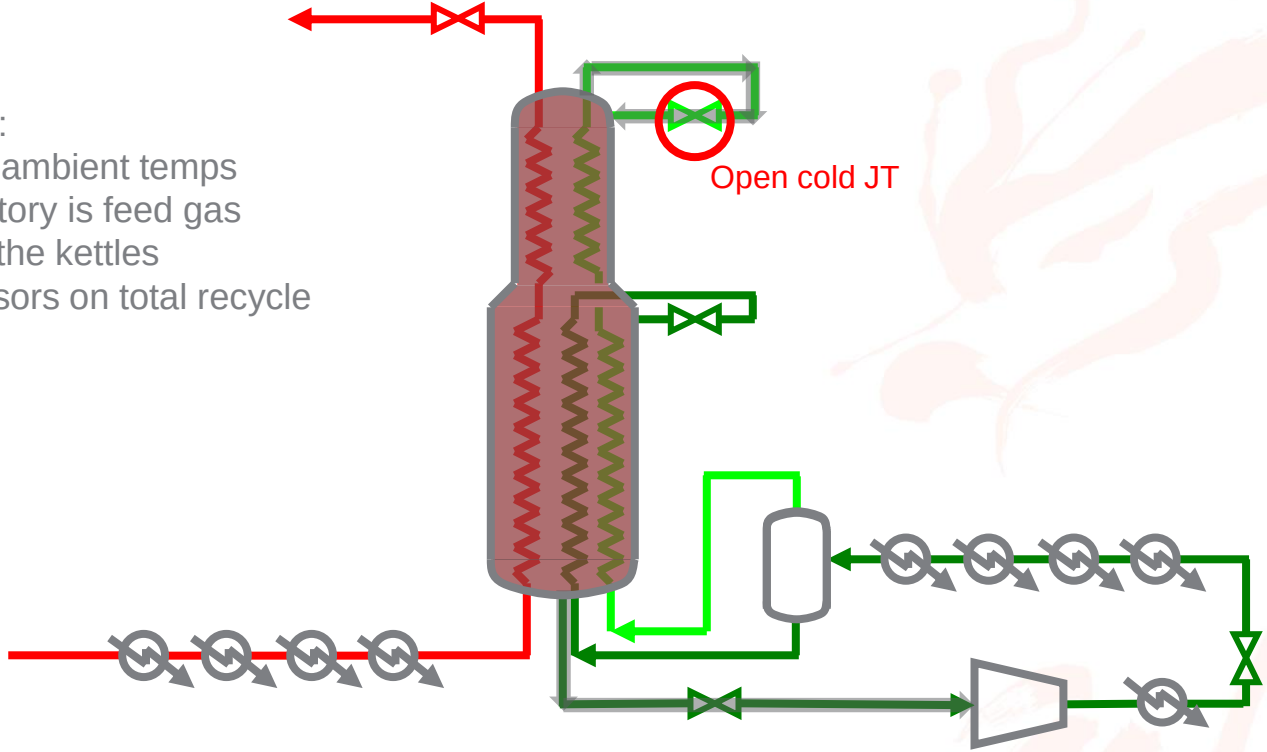
How Can We Simplify the LNG Cooldown Process?

- Eliminate the precooldown step
- Reduce flaring for environmental and cost reasons
- Simplify operator interactions
- Minimize time to LNG production

Reduced Flaring Cooldown: Open Cold JT Valve

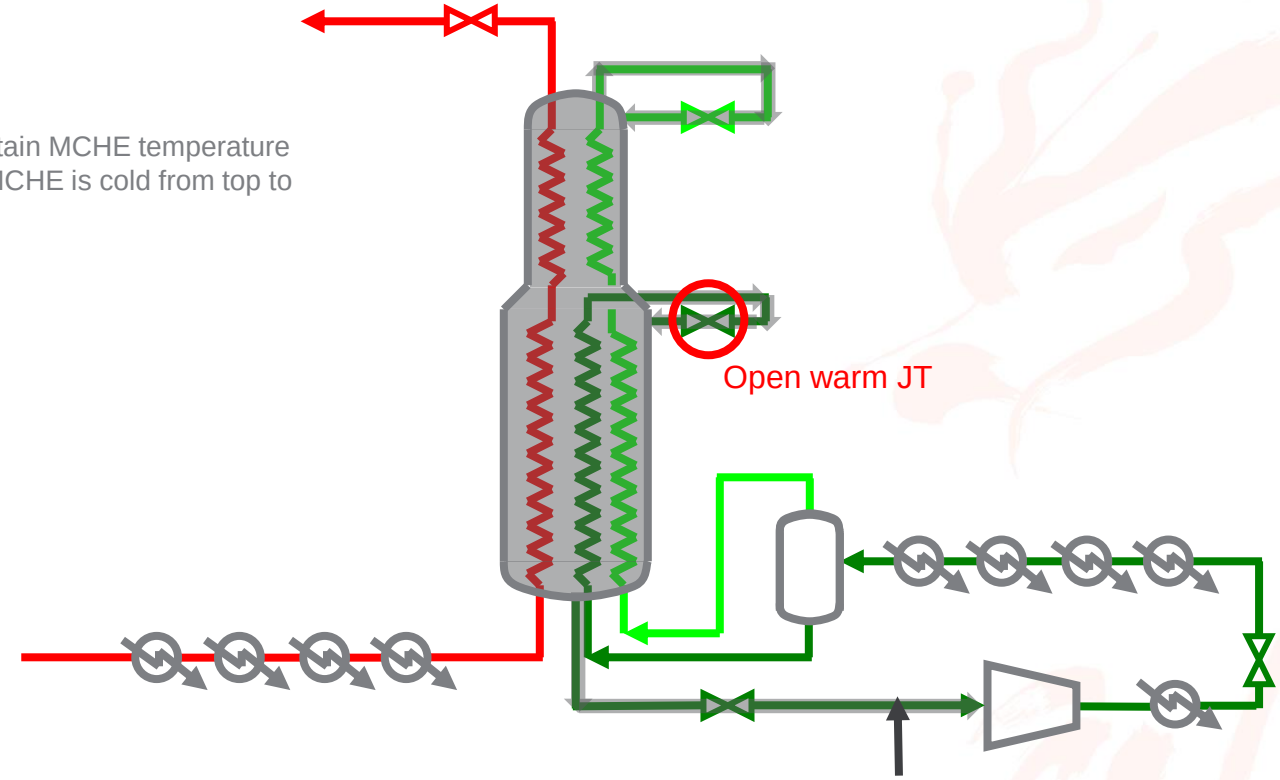
Starting point:

- MCHE at ambient temps
- MR inventory is feed gas
- No C3 in the kettles
- Compressors on total recycle

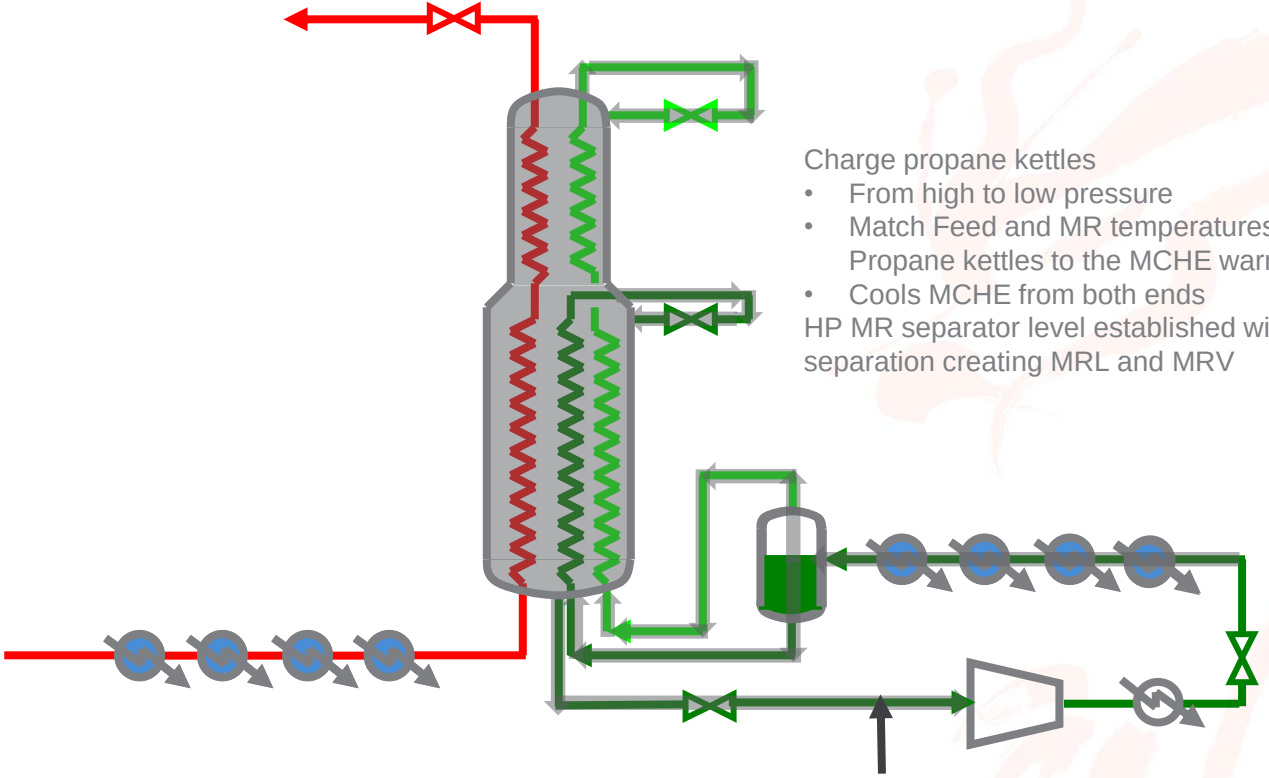


Reduced Flaring Cooldown: Open Warm JT Valve

Goal: maintain MCHE temperature profile so MCHE is cold from top to bottom.



Reduced Flaring Cooldown: Charge Propane



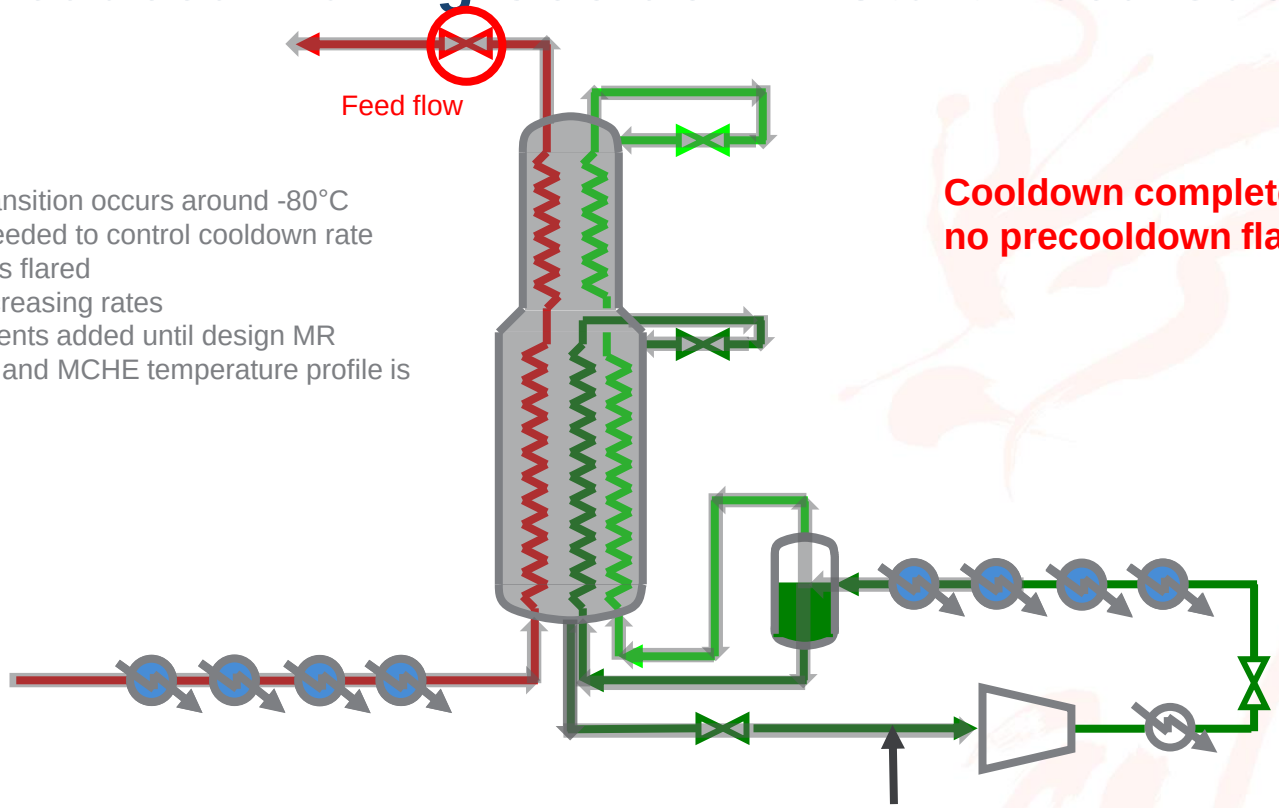
Charge propane kettles
- From high to low pressure
- Match Feed and MR temperatures from the Propane kettles to the MCHE warm end
- Cools MCHE from both ends

HP MR separator level established with phase separation creating MRL and MRV

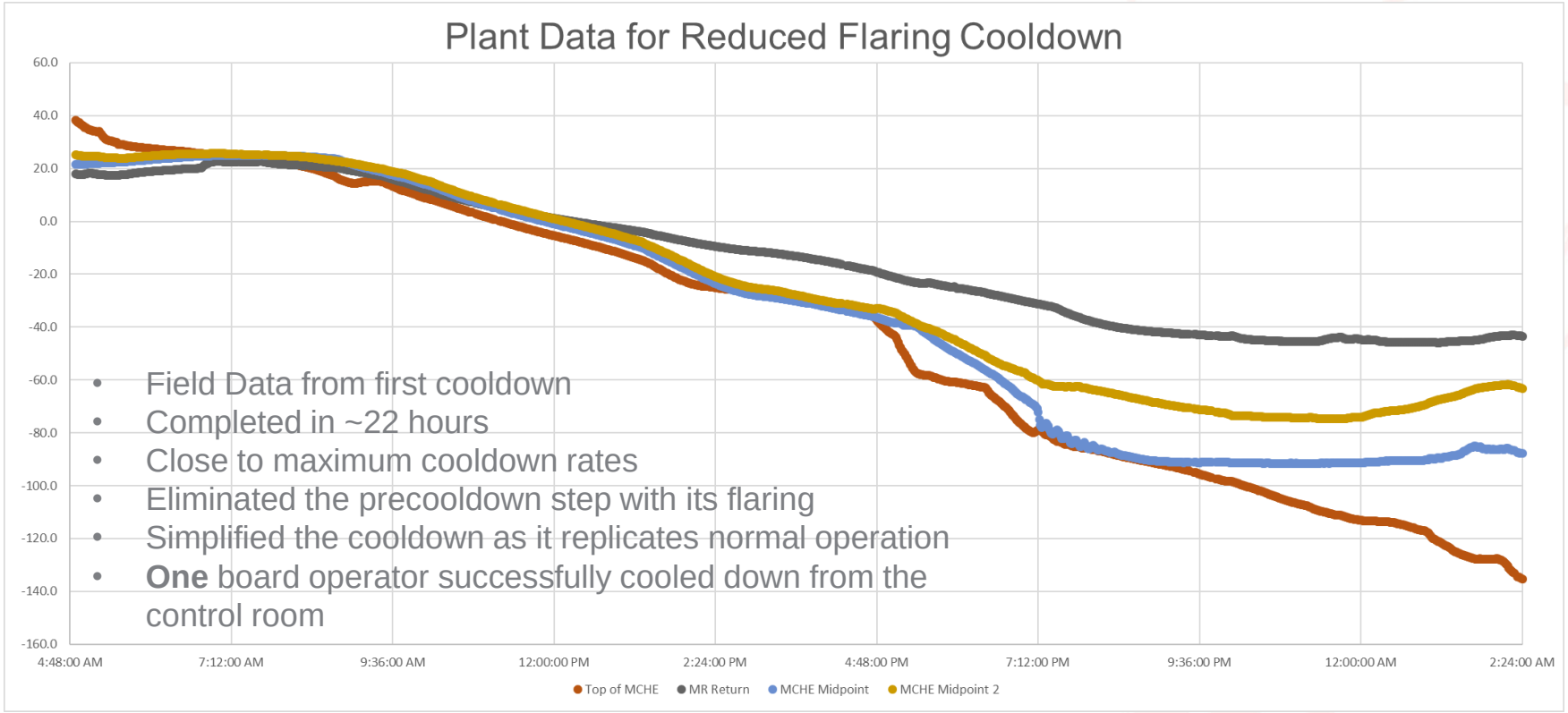
Add C1, C2, C3 continuously.

Reduced Flaring Cooldown: Start Feed Gas

- MR liquid transition occurs around -80°C
- Feed flow needed to control cooldown rate
- Warm LNG is flared
- Continue increasing rates
- MR components added until design MR composition and MCHE temperature profile is achieved



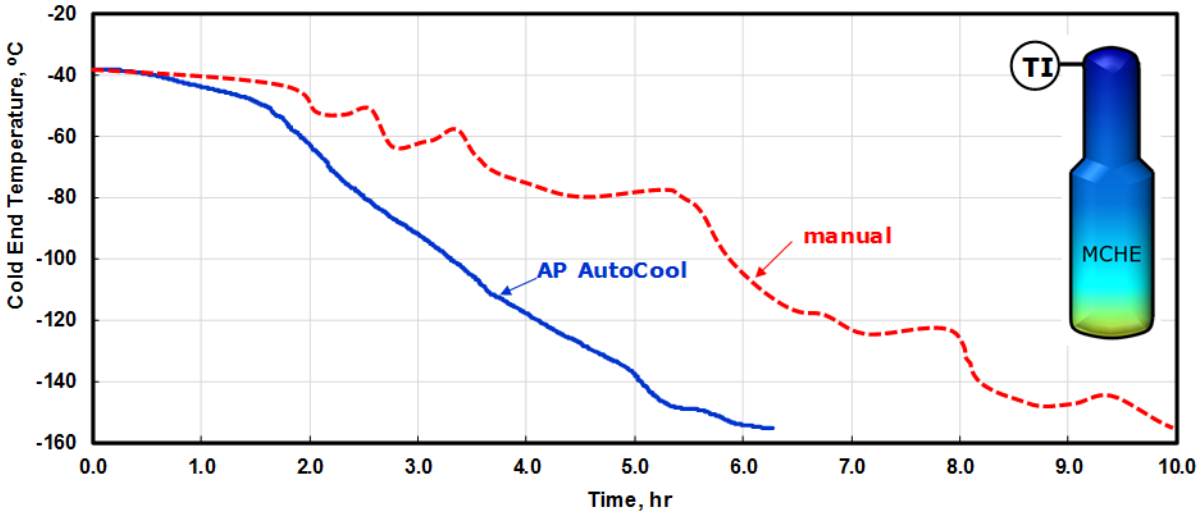
Cooldown complete with no precooldown flaring!


Plant Data for Reduced Flaring Cooldown
60.0
40.0
20.0
0.0
-20.0
-40.0
-60.0
-80.0
-100.0
-120.0
-140.0
-160.0
4:48:00 AM
7:12:00 AM
9:36:00 AM
12:00:00 PM
2:24:00 PM
4:48:00 PM
7:12:00 PM
9:36:00 PM
12:00:00 AM
2:24:00 AM
Top of MCHE
MR Return
MCHE Midpoint
MCHE Midpoint 2
• Field Data from first cooldown
• Completed in ~22 hours
• Close to maximum cooldown rates
• Eliminated the precooldown step with its flaring
• Simplified the cooldown as it replicates normal operation
• **One** board operator successfully cooled down from the control room

The AP-Autocool™ Program

- To further enhance the cooldown program Air Products developed the AP-AutoCool™ Program
- Automatically cools the MCHE from ambient to operating temperature
- Utilizes the existing valves and instrumentation
- Simple control algorithms
- Maintains optimal cooldown rate at AP guideline
- Reduces cooldown time to minimize LNG flaring
- Provides consistent and repeatable cooldowns

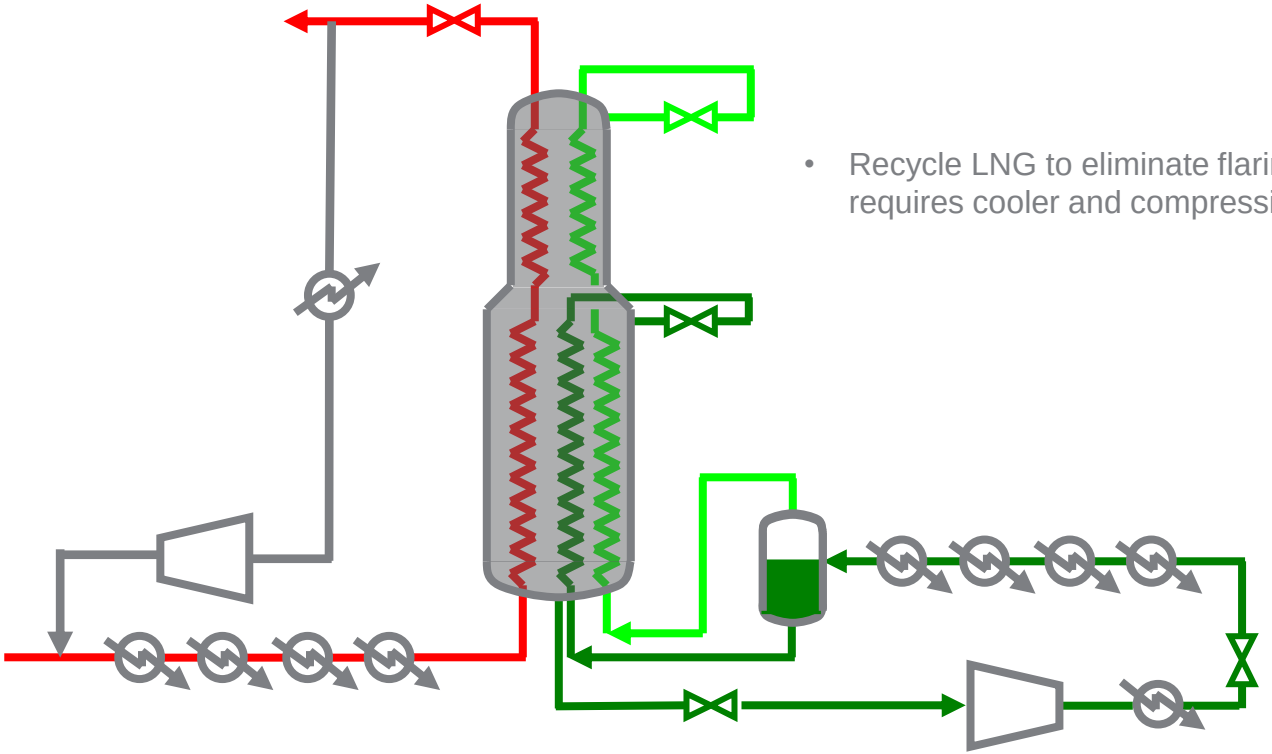
Results of AP Autocool



LNG Recycle

- Final option for flare reduction is to recycle the off-spec LNG back to front end
- Heat exchanger needed to vaporize the LNG and warm the stream
- Utilize an existing recycle compressor if available

LNG Recycle



- Recycle LNG to eliminate flaring but requires cooler and compression

Summary

- Reduced Flaring Cooldown, accomplished by staging the propane kettles, is a time and cost saving method to effectively cooldown the MCHE and liquefaction train.
  - Eliminates the precooldown step with its flaring
  - Allows one operator to complete the cooldown
  - Has been successfully demonstrated on multiple operating plants
- The AP-Autocool™ Program achieves the maximum permissible cooldown rate with reduced off-spec LNG flaring.
- Adding LNG recycle can virtually eliminate flaring during start-up.

Thank You