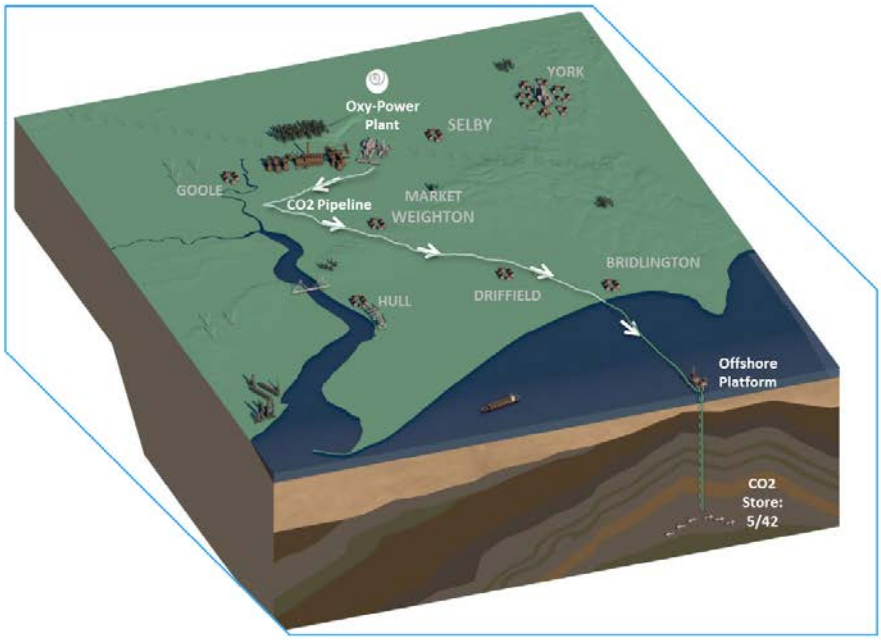
December 2015

WHITE ROSE

K22: Full Chain Process Flow Diagrams

Technical: Full Chain



CAPTURE POWER

drax

BOC
A Member of The Linde Group

nationalgrid

Contents

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Key Words

Key Work	Meaning or Explanation
Carbon Dioxide	A greenhouse gas produced during the combustion process
Carbon Capture and Storage	A technology which reduces carbon emissions from the combustion based power generation process and stores it in a suitable location
Coal	The fossil fuel used in the combustion process for White Rose
Dense Phase	Fluid state that has a viscosity close to a gas while having a density closer to a liquid Achieved by maintaining the temperature of a gas within a particular range and compressing it above a critical pressure
Full Chain	A complete CCS system from power generation through CO_2 capture, compression, transport to injection and permanent storage
Heat and Mass Balance	Heat and mass balance/heat and materials balance is a document produced by process design engineers while designing a process plant. A heat and mass balance sheet represents every process stream on the corresponding process flow diagram in terms of the process conditions.
Key Knowledge	Information that may be useful if not vital to understanding how some enterprise may be successfully undertaken
Storage	Containment in suitable pervious rock formations located under impervious rock formations usually under the sea bed
Transport	Removing processed CO_2 by pipeline from the capture and process unit to storage
Operation	Utilising plant/equipment to produce/provide the designed output commodity/service
Operating Mode	The method of operation of the OPP, which can operate in air or oxy-firing mode
Oxy Boiler	The boiler within the OPP capable of producing full load in either the air or oxy-fired mode of operation
Oxy-firing	The use of oxygen (instead of air) in the combustion process
Oxyfuel	The technology where combustion of fuel takes place with oxygen replacing air as the oxidant for the process, with resultant flue gas being high in CO_2
Oxy Power Plant	A power plant using oxyfuel technology
Process Flow Diagram	Process Flow Diagram (PFD) is a drawing which describes the process flow for a processing plant. PFD is used to capture the main process equipment and main process streams in a single drawing.
White Rose	The White Rose Carbon Capture and Storage project

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Figures

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Executive Summary

The Full Chain Process Flow Diagrams were generated as part of the Front End Engineering Design (FEED) contract with the Department of Energy and Climate Change (DECC) for White Rose, an integrated full-chain Carbon Capture and Storage (CCS) Project. This document is one of a series of Key Knowledge Deliverables (KKD) from White Rose to be issued by DECC for public information.

White Rose comprises a new coal-fired ultra-supercritical Oxy Power Plant (OPP) of up to 448 MWe (gross) and a Transport and Storage (T&S) network that will transfer the carbon dioxide from the OPP by pipeline for permanent storage under the southern North Sea. The OPP captures around 90% of the carbon dioxide emissions and has the option to co-fire biomass.

Delivery of the project is through Capture Power Limited (CPL), an industrial consortium formed by General Electric (GE), BOC and Drax, and National Grid Carbon Limited (NGC), a wholly owned subsidiary of National Grid.

This report provides the Process Flow Diagrams covering the Full CCS Chain.

This document should be read in conjunction with the following documents:

- K.23 - Full Chain Heat and Material Balances;
- K.24 - Full Chain Equipment List;
- K.27 - OPP - Process Description;
- K.29 - Transport - Process Description;
- K.30 - Storage - Process Description; and
- K.35 - Onshore Pipeline Route Plans Report.

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1 Introduction

1.1 Background

The White Rose Carbon Capture and Storage (CCS) Project (White Rose) is an integrated full-chain CCS project comprising a new coal-fired Oxy Power Plant (OPP) and a Transport and Storage (T&S) network that will transfer the carbon dioxide from the OPP by pipeline for permanent storage under the southern North Sea.

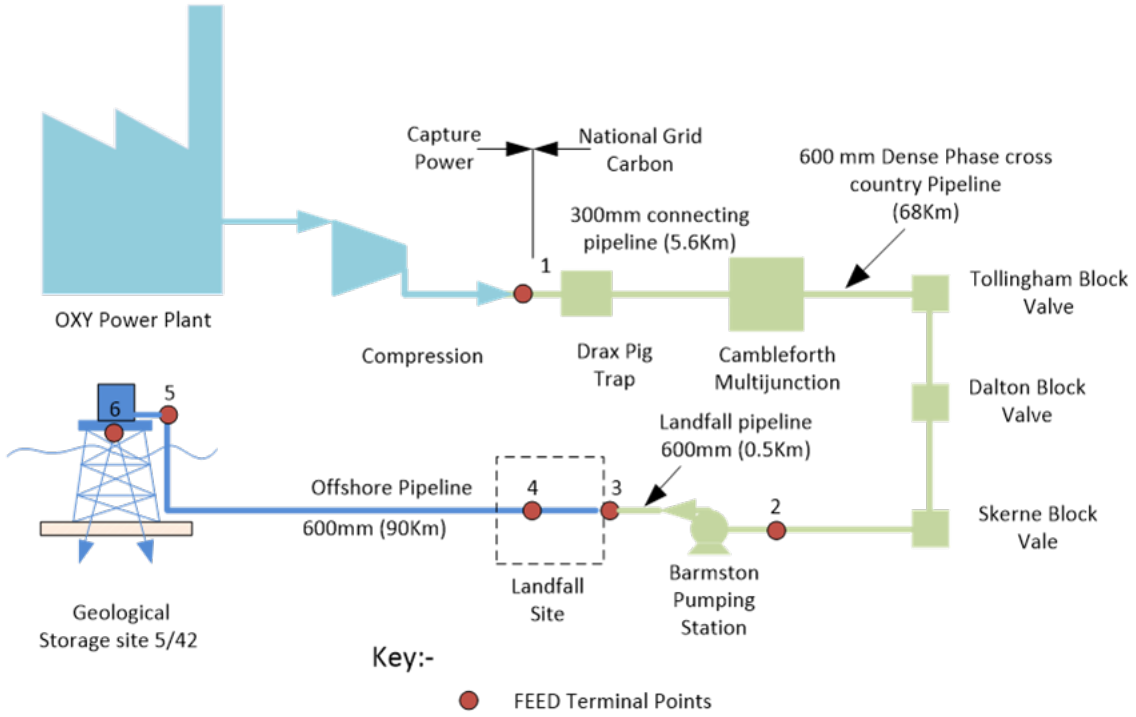
The OPP is a new ultra-supercritical power plant with oxyfuel technology of up to 448 MWe gross output that will capture around 90% of carbon dioxide emissions and also have the option to co-fire biomass.

One of the first large scale demonstration plants of its type in the world, White Rose aims to prove CCS technology at commercial scale as a competitive form of low-carbon power generation and as an important technology in tackling climate change. The OPP will generate enough low carbon electricity to supply the equivalent needs of over 630,000 homes.

White Rose is being developed by Capture Power Limited, a consortium of GE, BOC and Drax. The project will also establish a CO2 transportation and storage network in the region through the Yorkshire and Humber CCS pipeline being developed by National Grid Carbon Ltd (NGC).

The Full Chain and its component parts (see Figure 1.1) are designed to be operated such that the target of two million tonnes of CO2 per year can be safely stored.

Figure 1.1: Full Chain Schematic Diagram



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2 Process Flow Diagrams

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Figure 2.1: Full Chain Block Flow Diagram and Overall Stream Summary

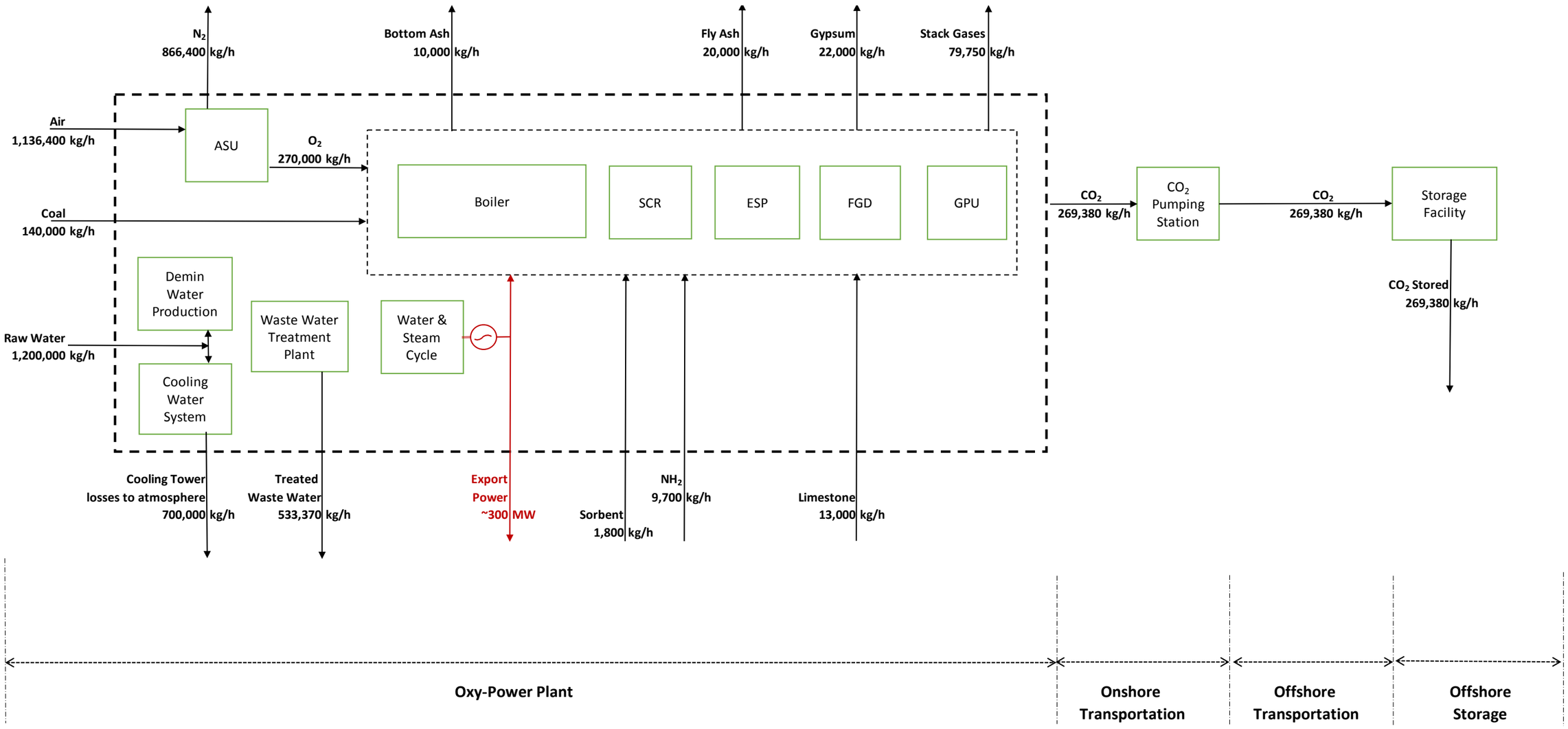

Figure 2.2: Process Flow Diagram - Water Steam Cycle system

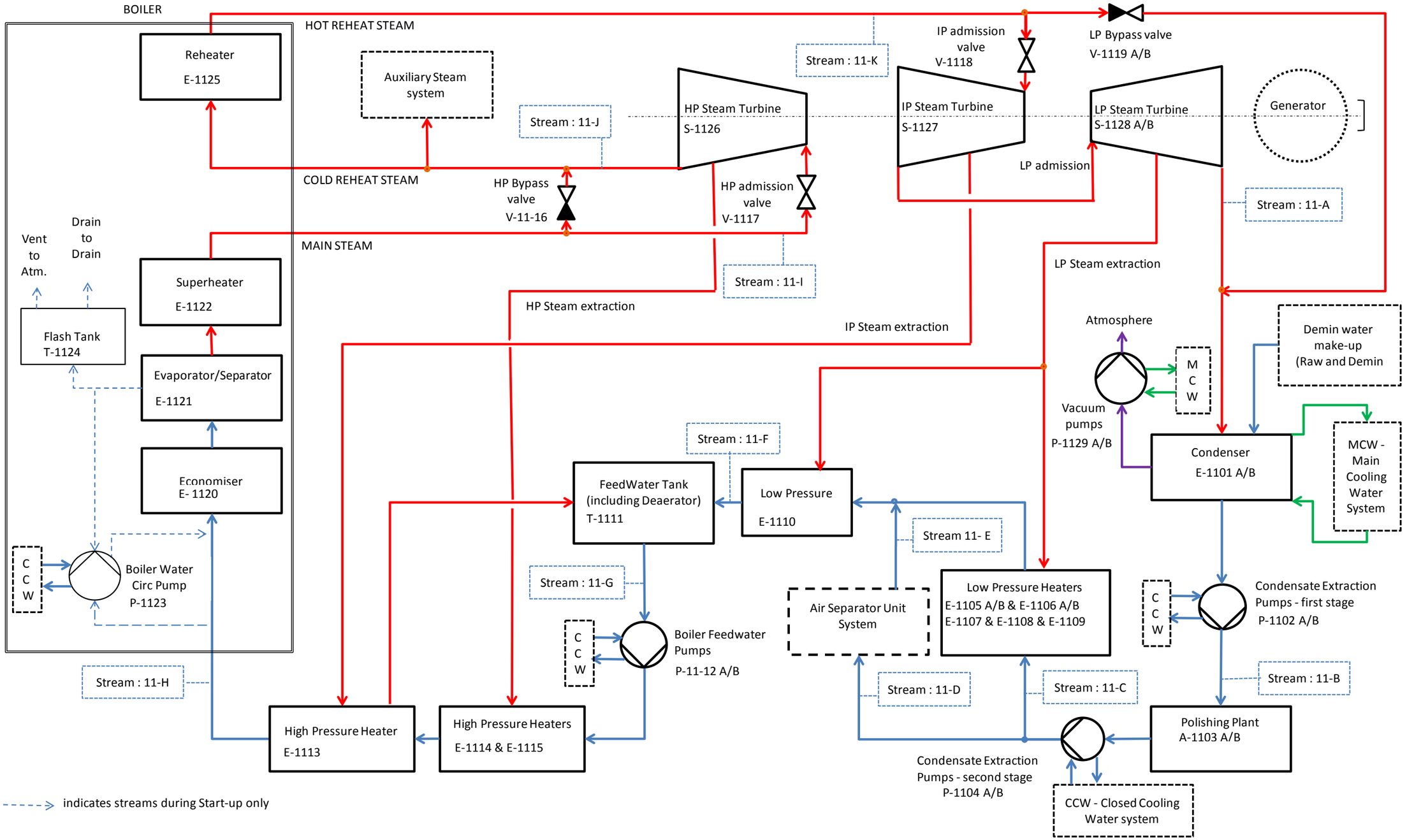

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Figure 2.3: Process Flow Diagram - Air, Oxygen, CO_2 and Flue gas system

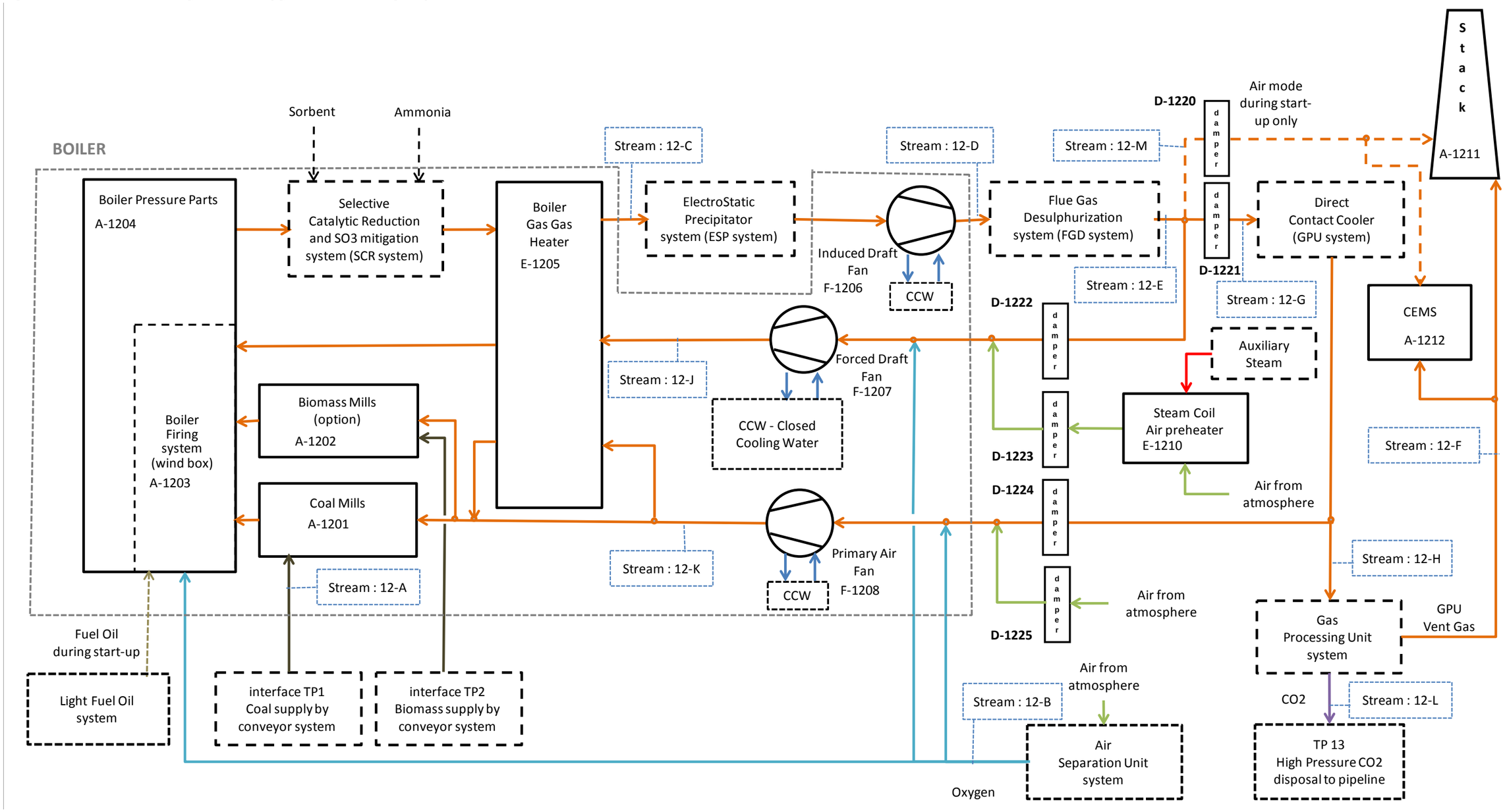

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Figure 2.4: Process Flow Diagram - Auxiliary Steam system

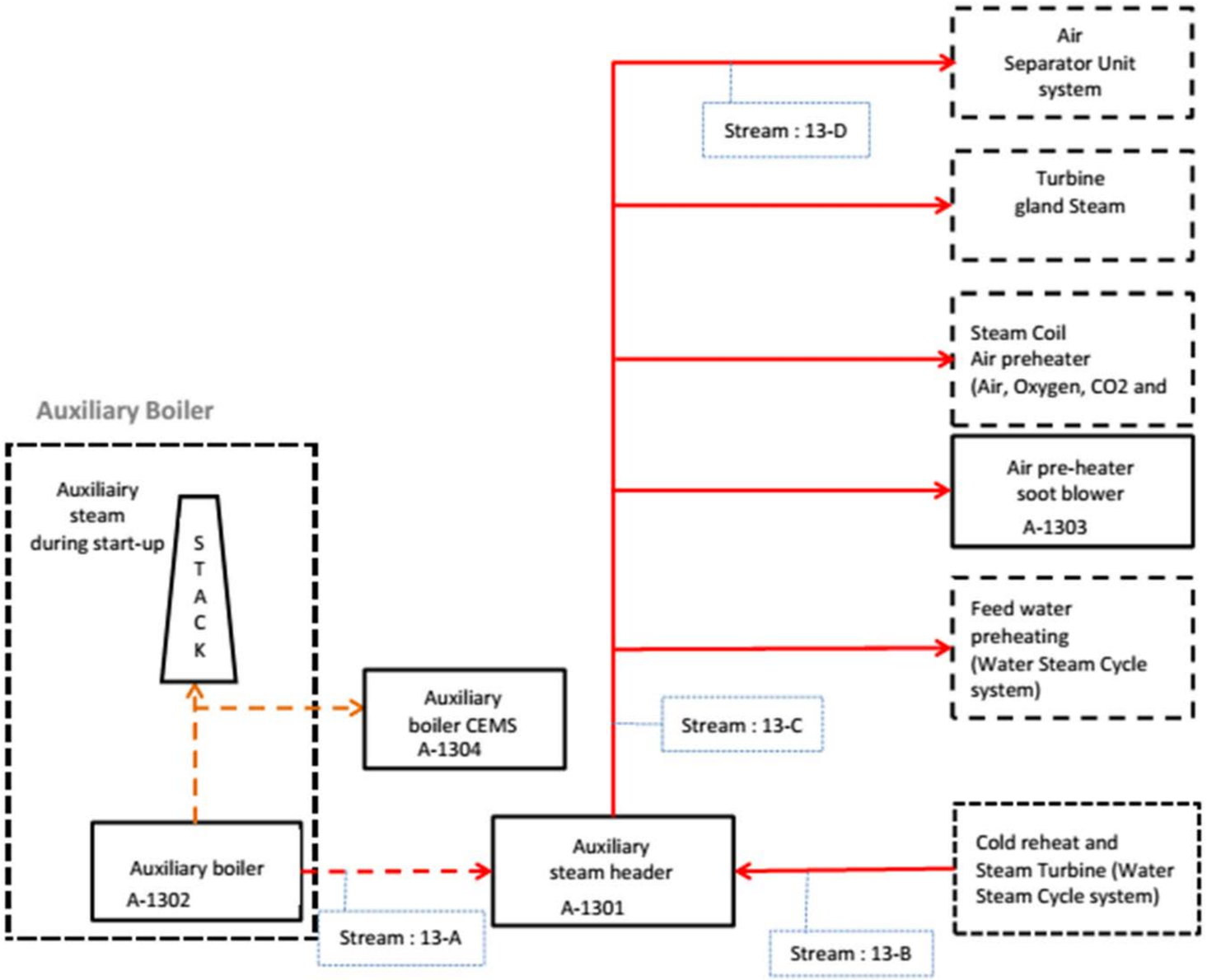

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Figure 2.5: Process Flow Diagram - Main Cooling Water system

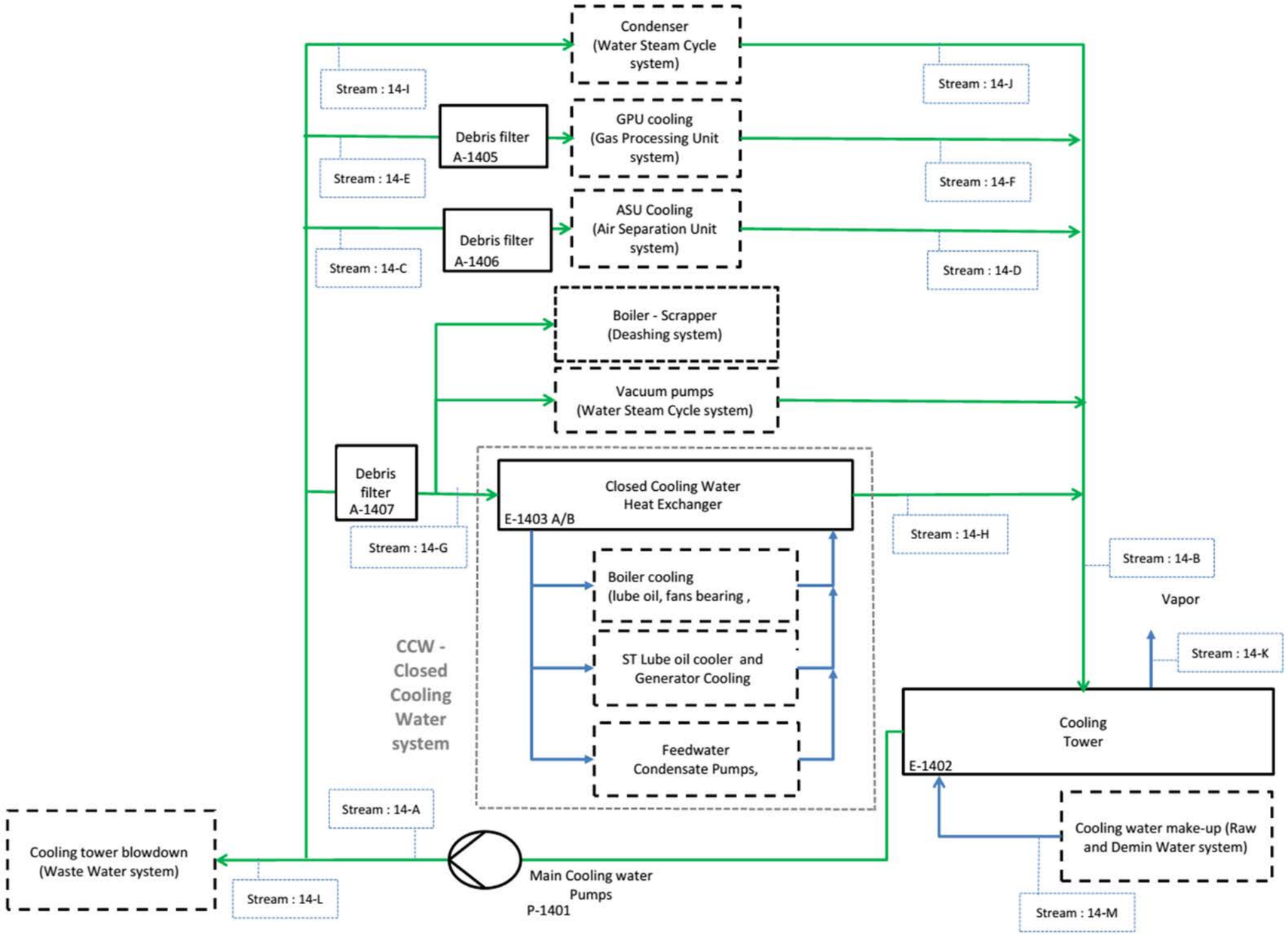

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Figure 2.6: Process Flow Diagram - Raw and Demineralised Water system

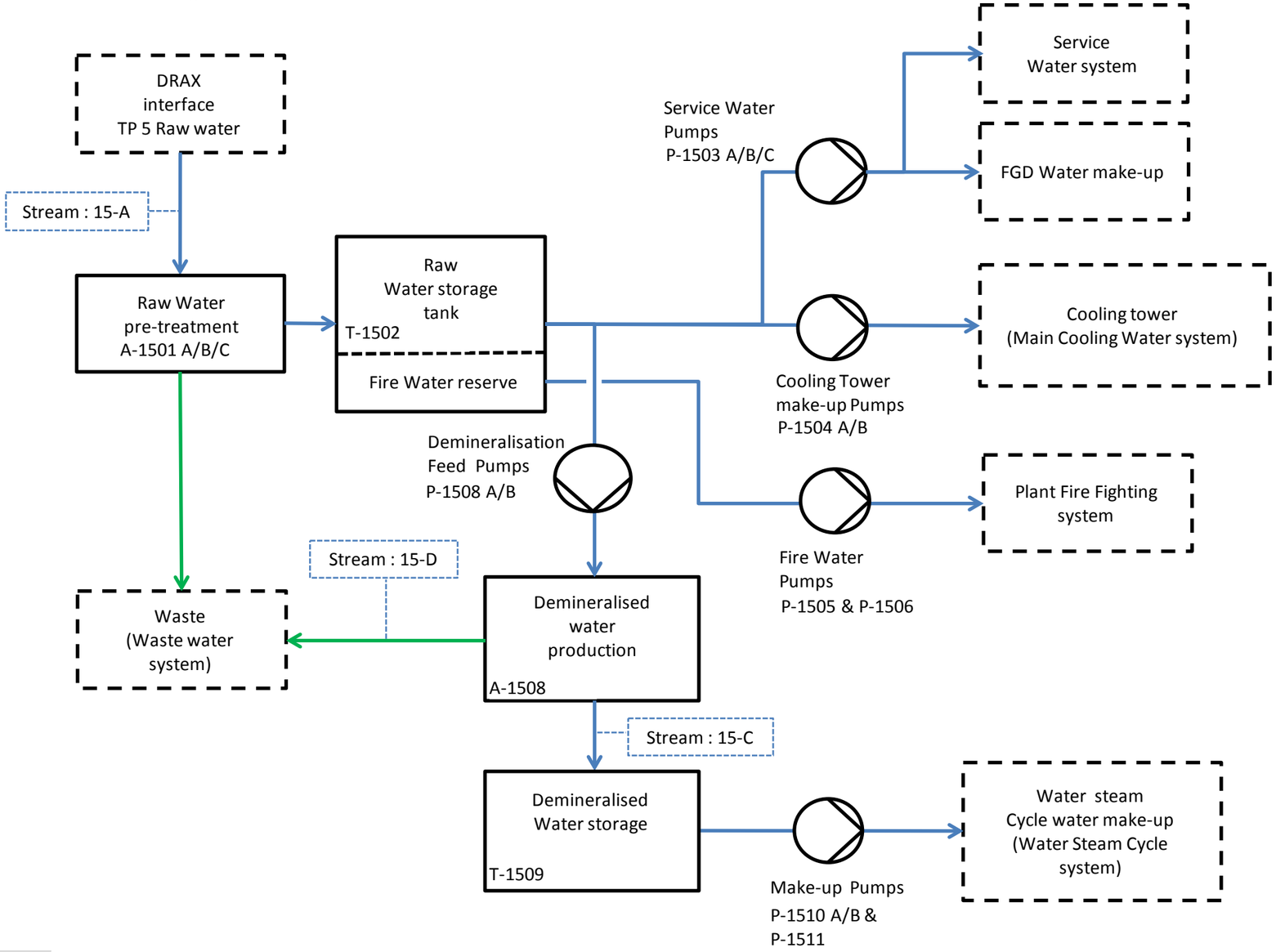

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Figure 2.7: Process Flow Diagram - Waste Water system

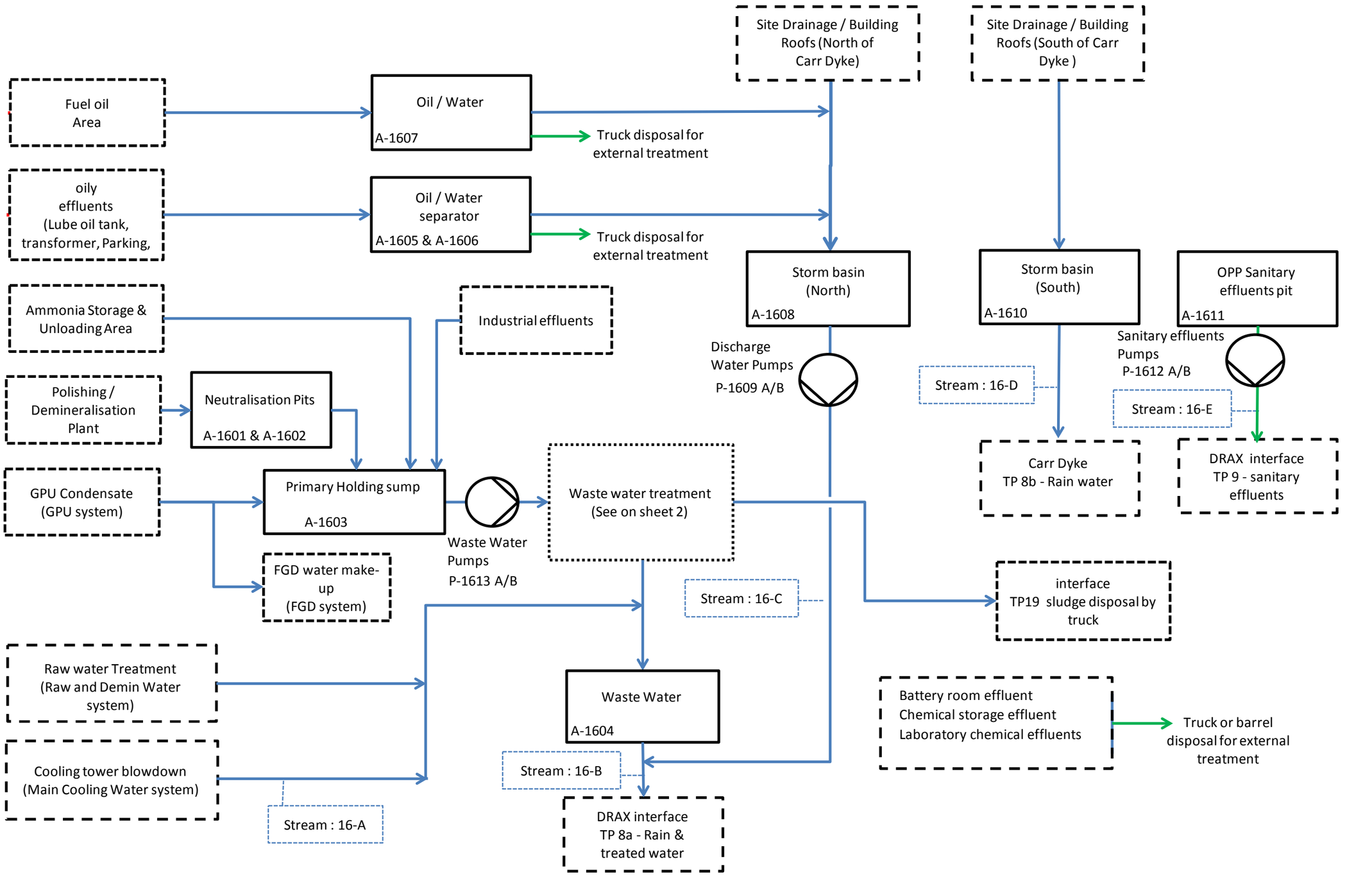

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Figure 2.8: Process Flow Diagram - Waste Water system

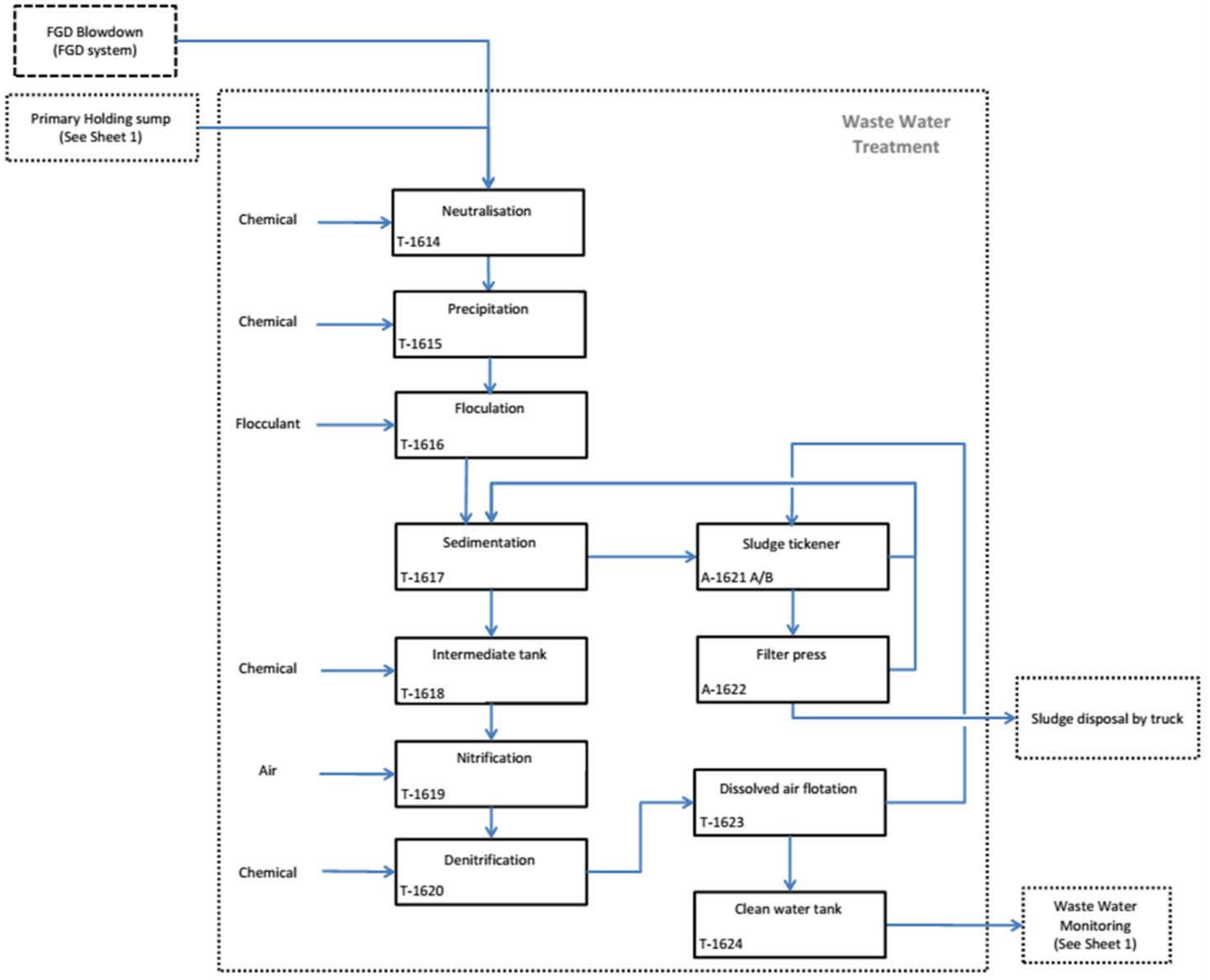

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Figure 2.9: Process Flow Diagram - Light Fuel Oil system

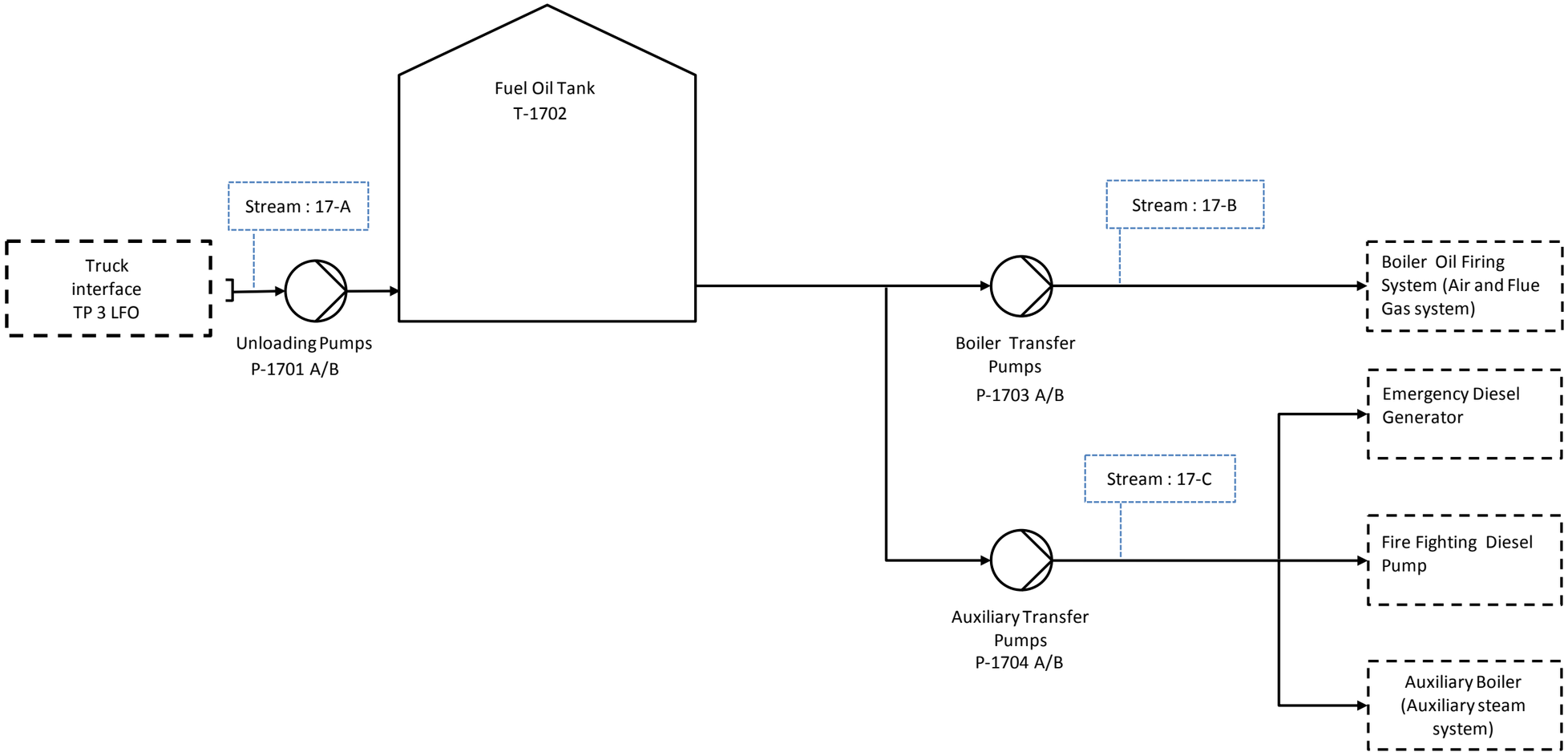

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Figure 2.10: **Process Flow Diagram - ElectroStatic Precipitator system**

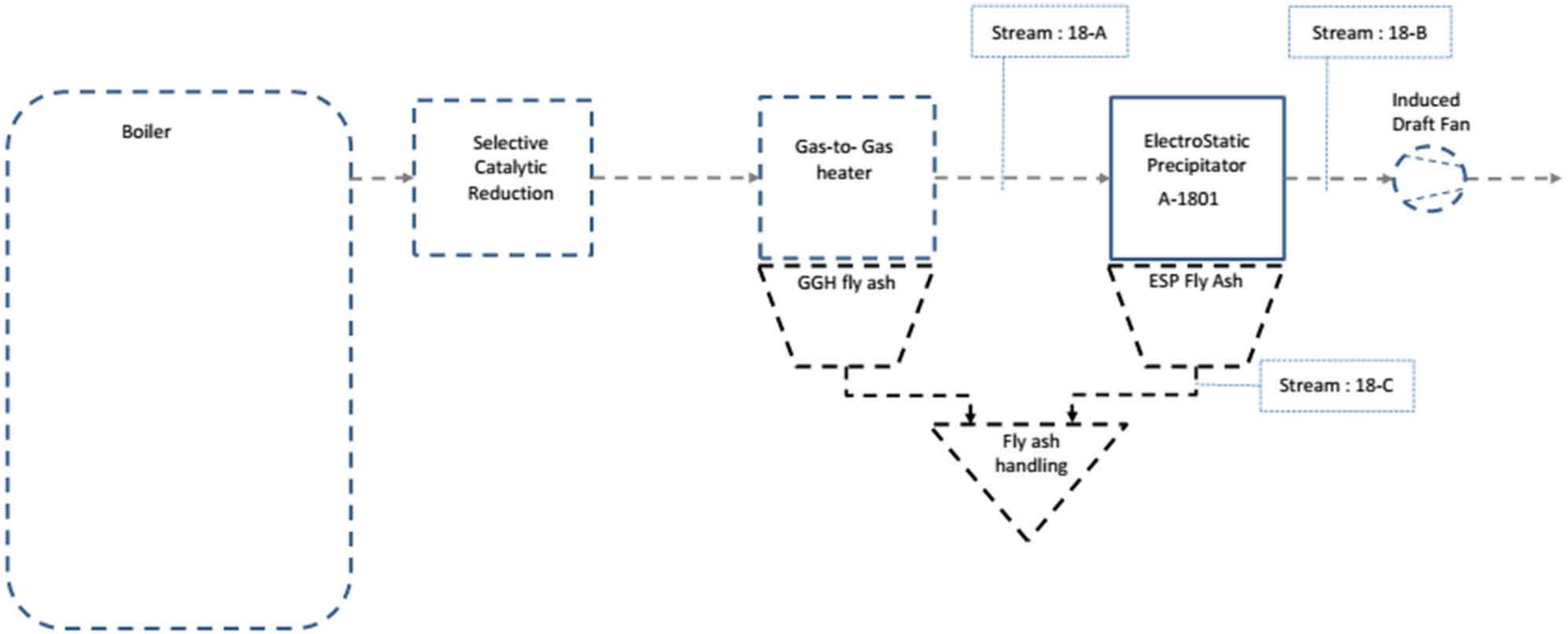

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Figure 2.11: Process Flow Diagram - Deashing system

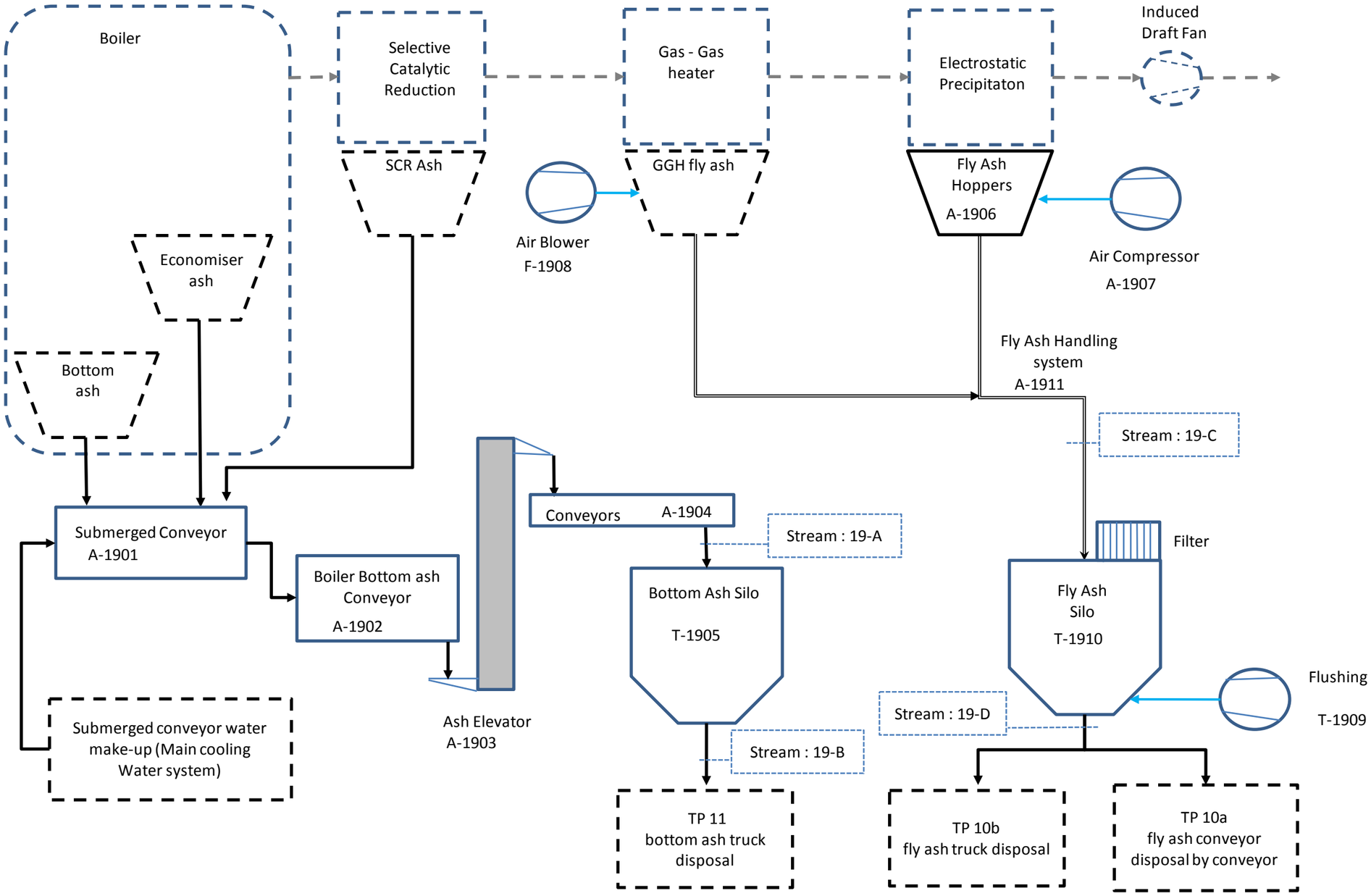

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Figure 2.12: Process Flow Diagram - Flue Gas Desulphurisation system

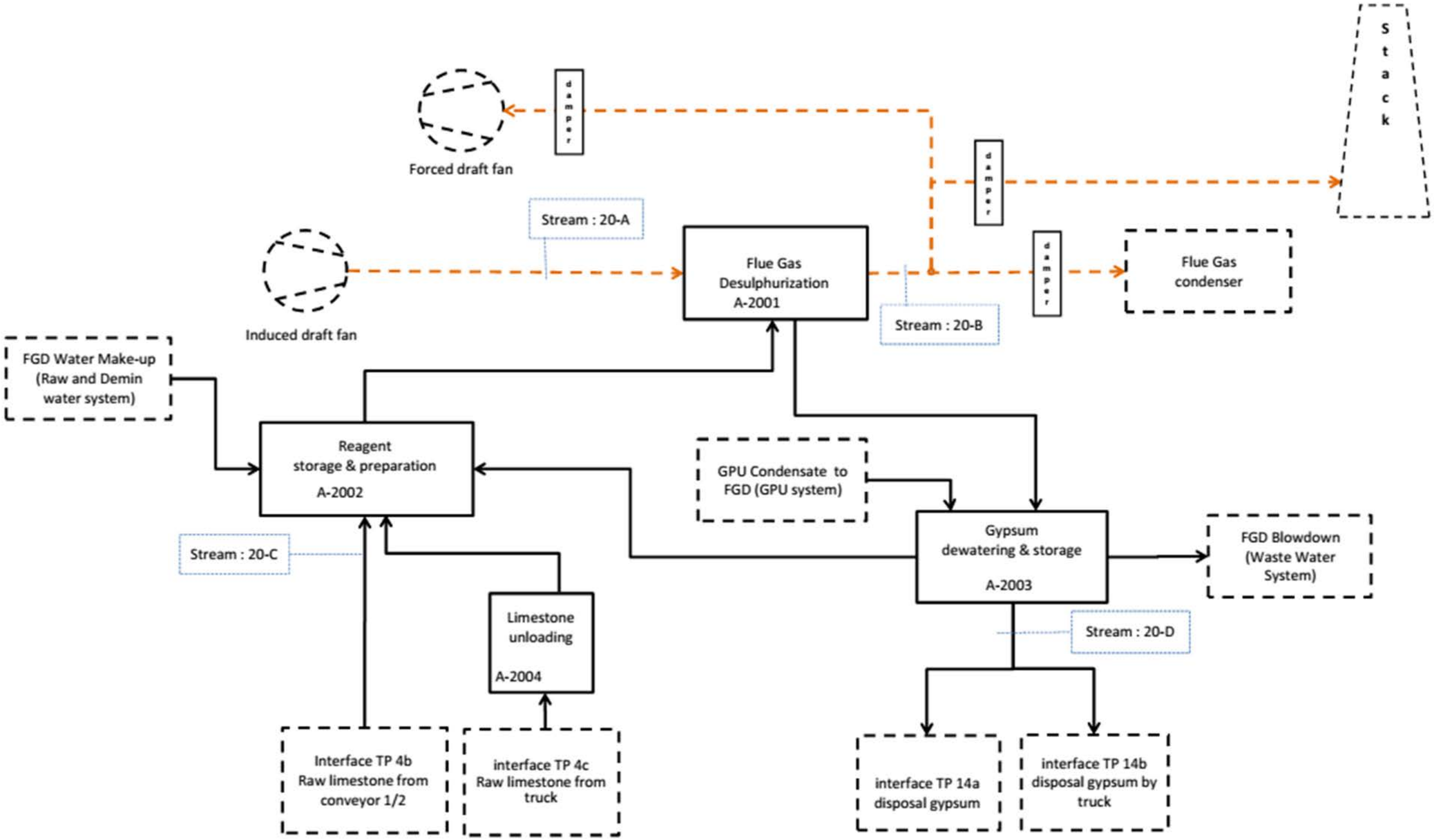

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Figure 2.13: Process Flow Diagram - Gas Processing Unit system

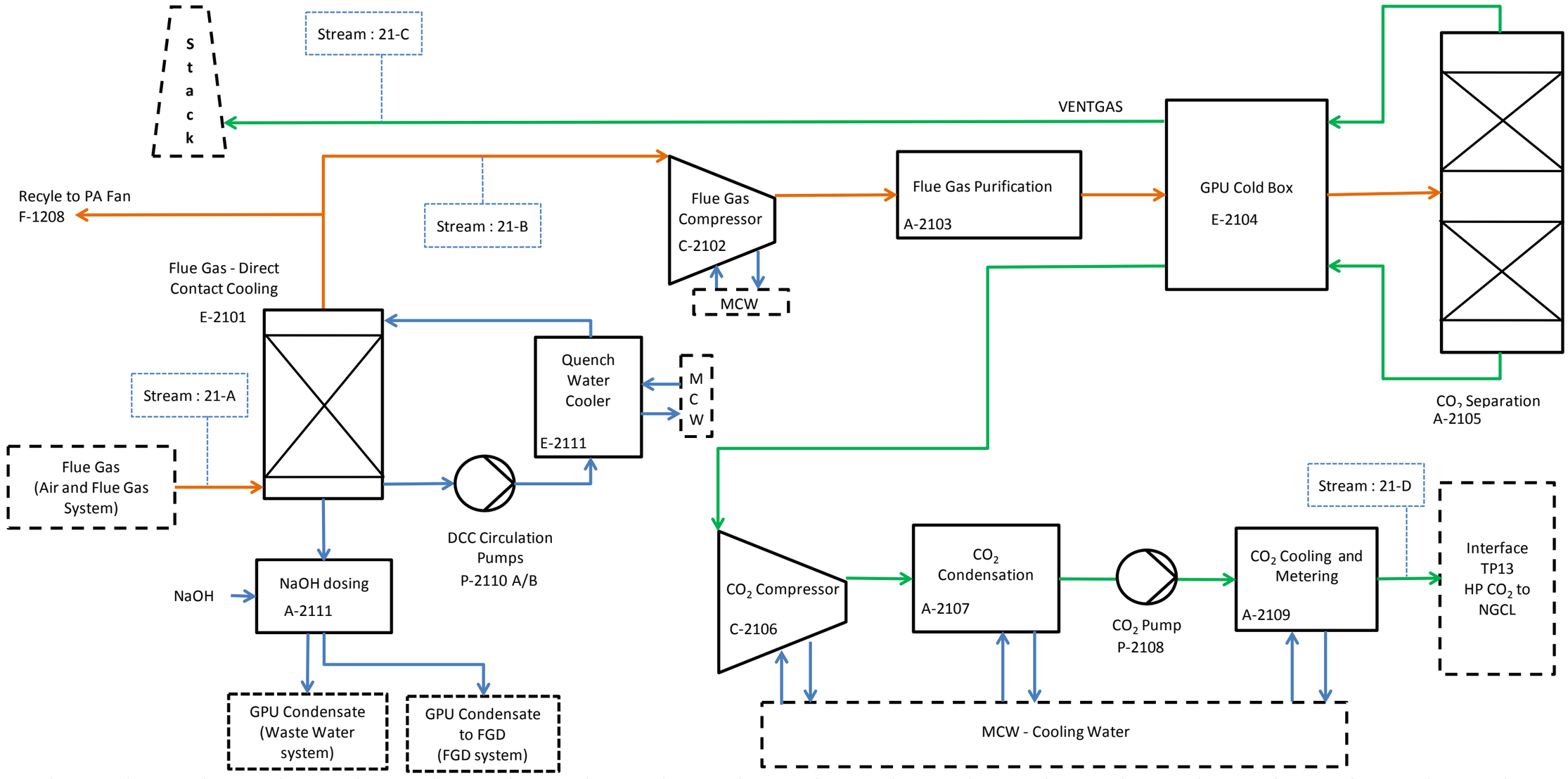

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Figure 2.14: Process Flow Diagram - Selective Catalyst Reducer system

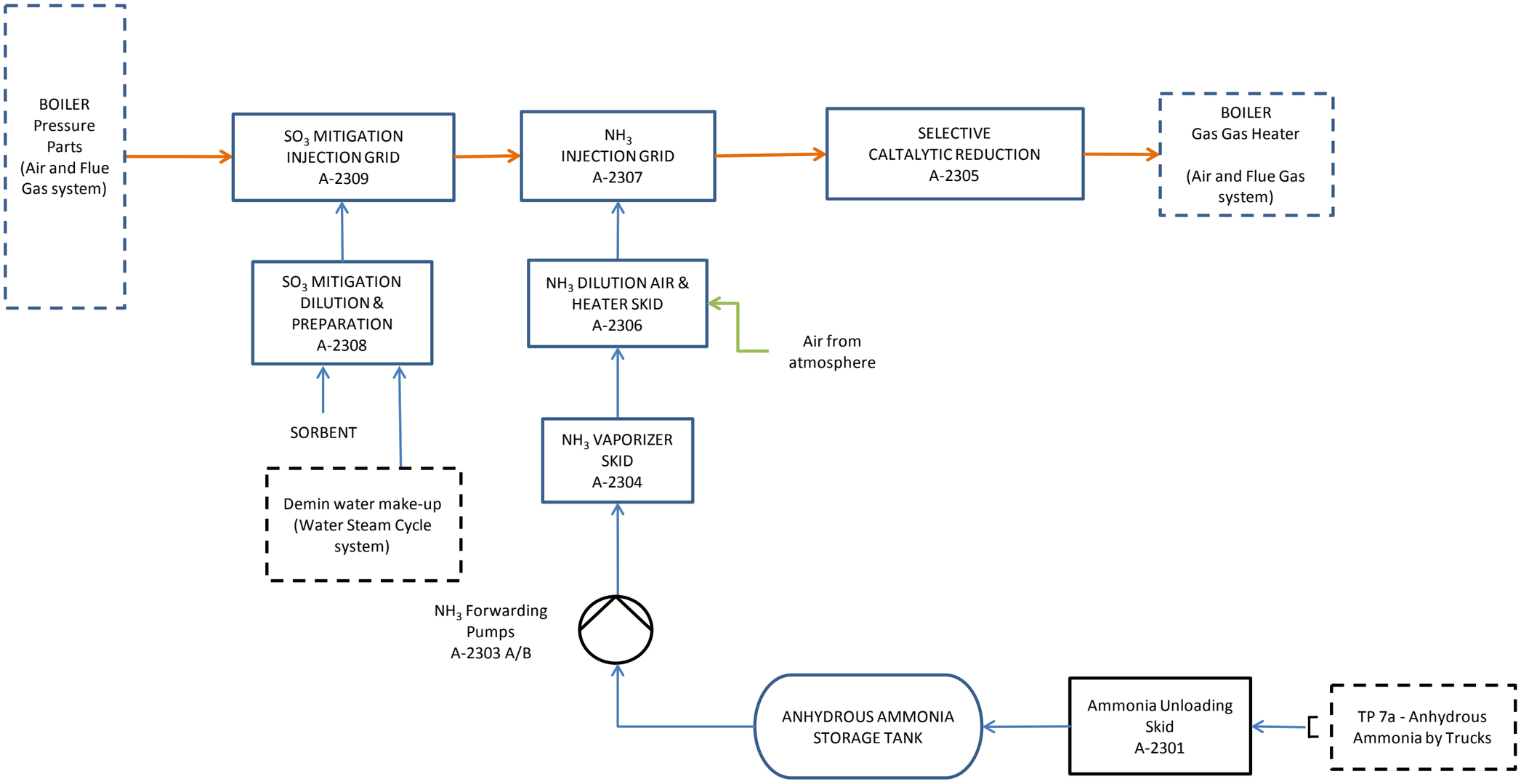

Figure 2.15: Air Separation Plant – 1 Train of 2

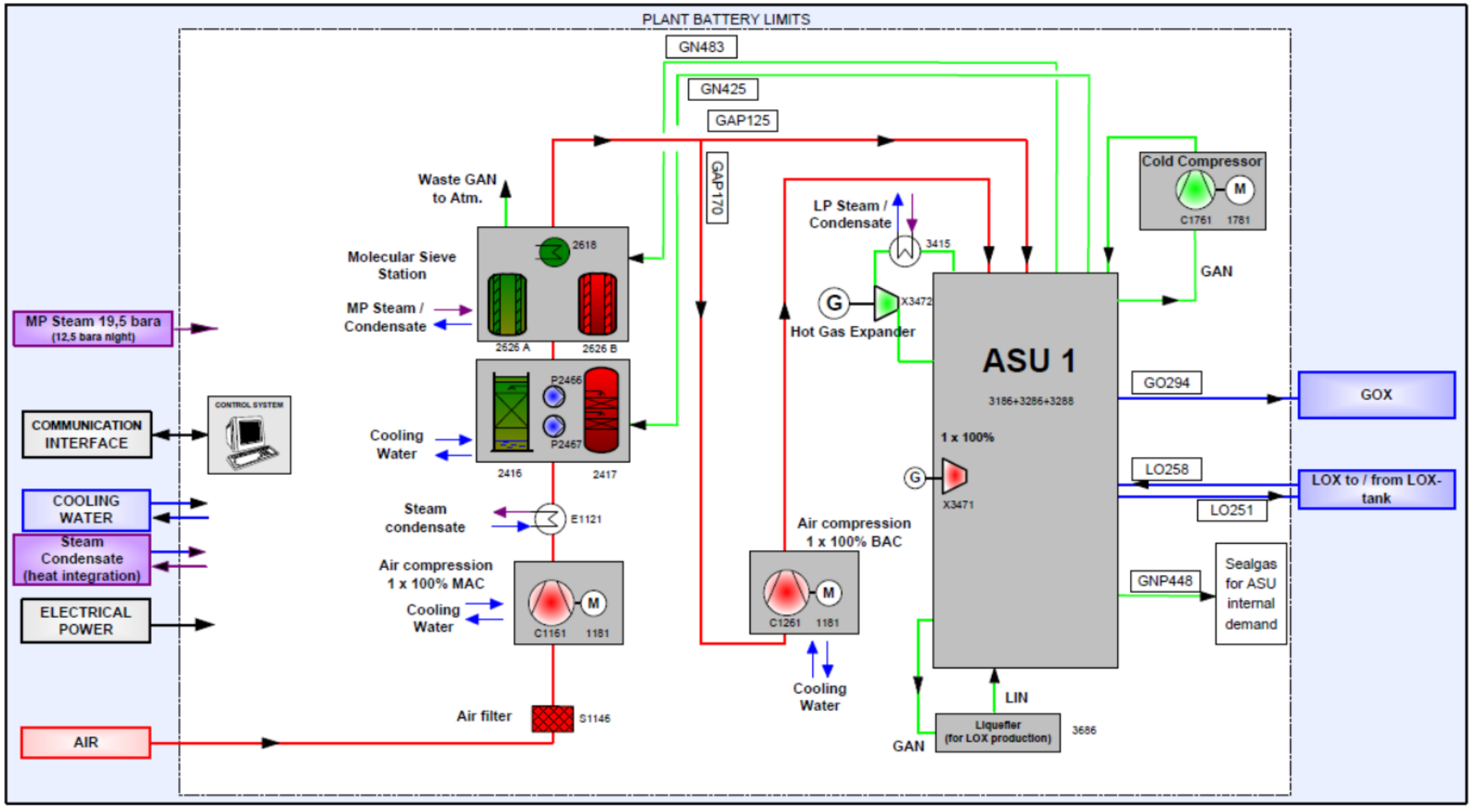

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Figure 2.16: Air Separation Plant – Full System

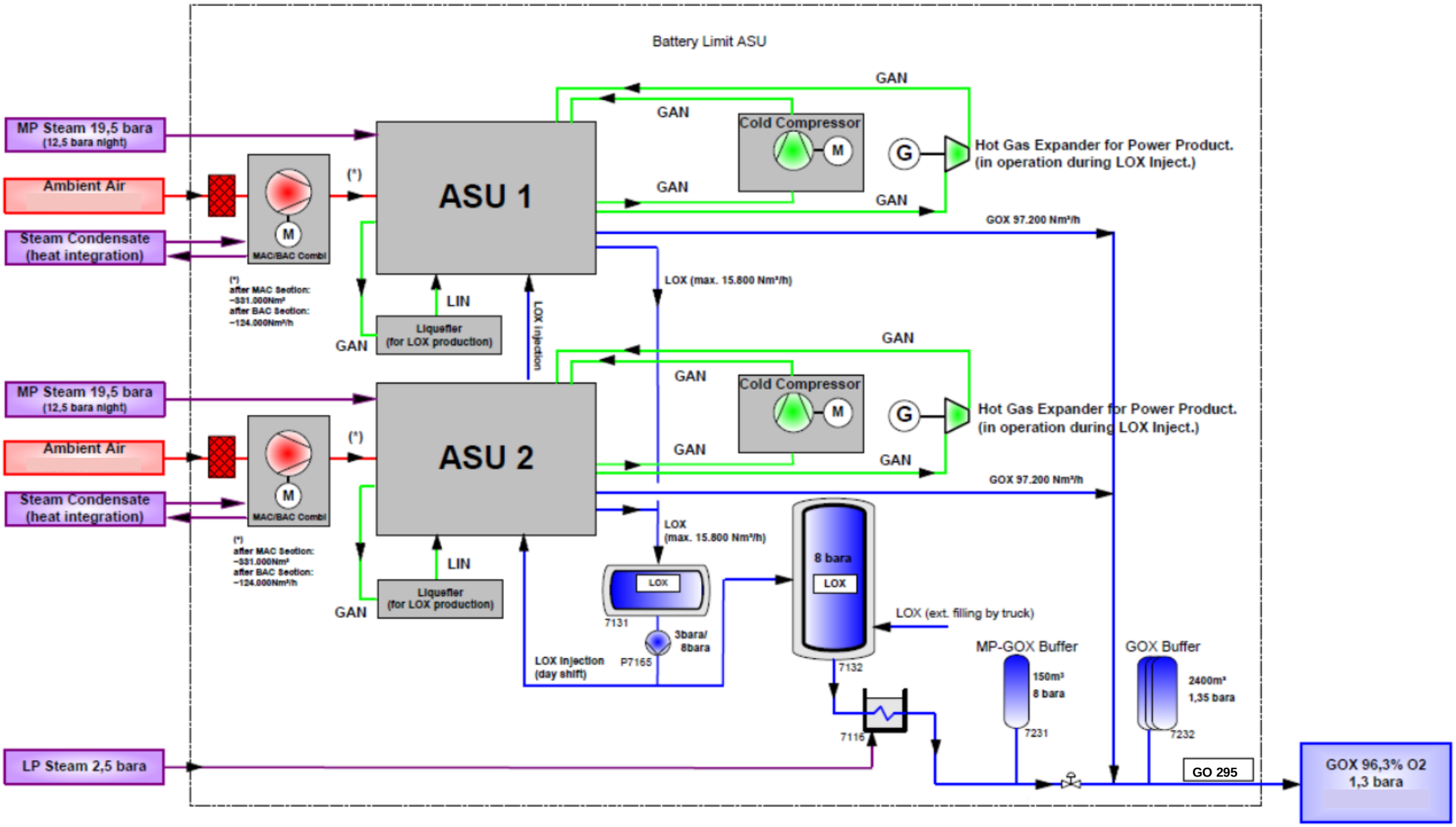

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Figure 2.17: Onshore Transportation Block Flow Diagram

(T&S Drawing reference: C001/15/30/99/GD000/0001)

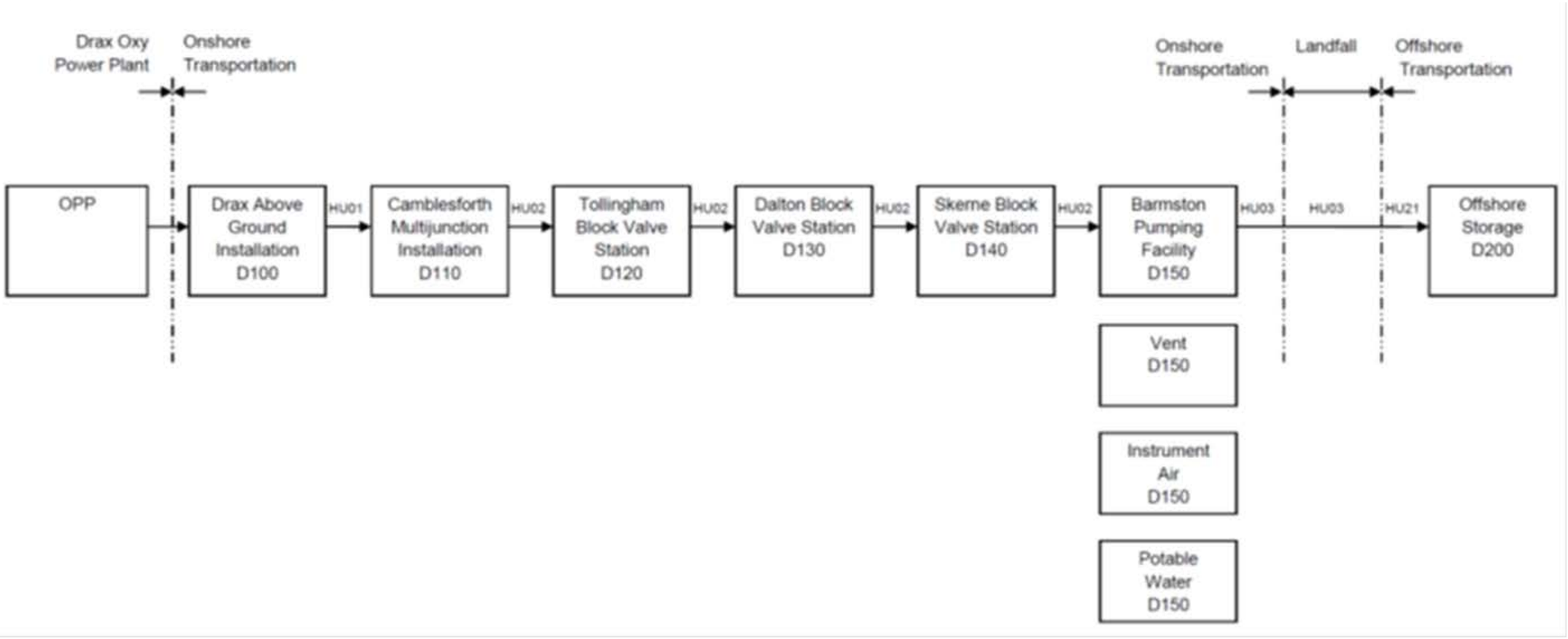

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Figure 2.18: Camblesforth Multijunction Process Flow Diagram

(T&S Drawing reference: C001/15/05/99/GHU01/0001)

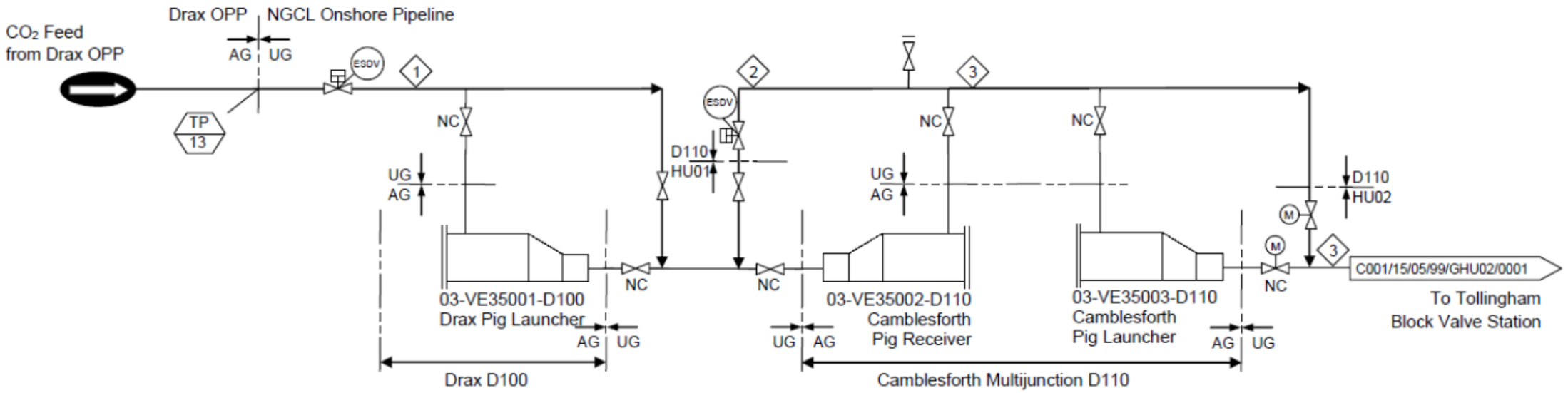

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Figure 2.19: Tollingham, Dalton and Skerne Block Valve Stations Process Flow Diagram

(T&S Drawing reference: C001/15/05/99/GHU02/0001)

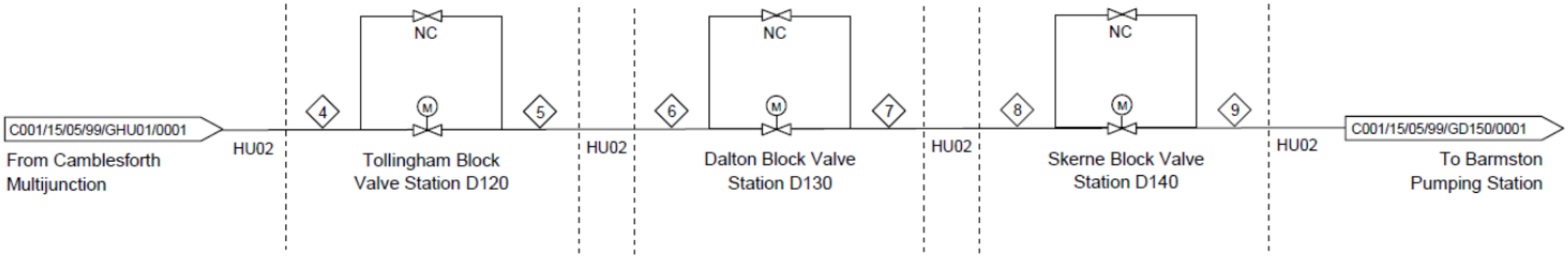

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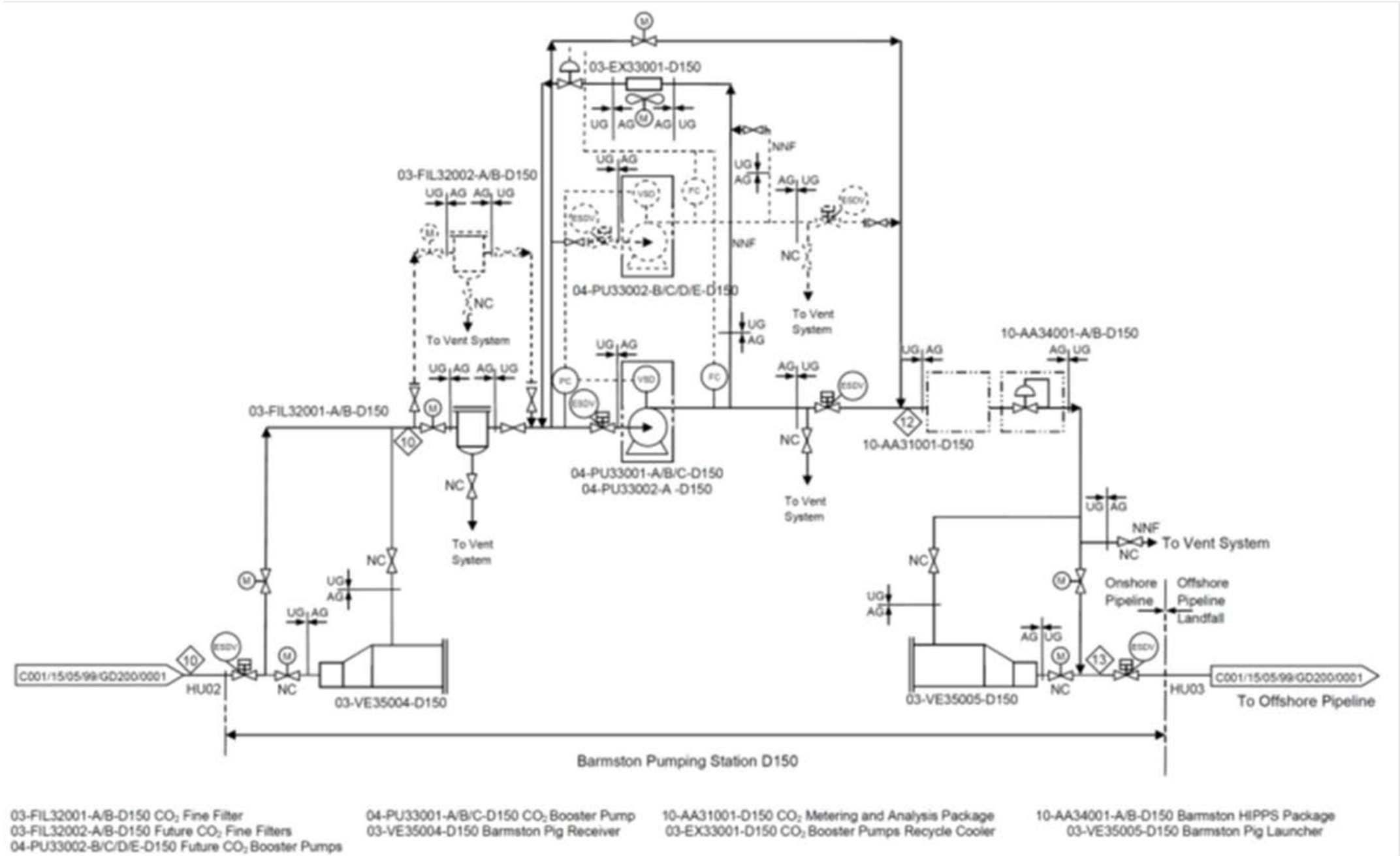
Figure 2.20: Barmston Pumping Station Process Flow Diagram

(T&S Drawing reference: C001/15/05/99/GD150/0001)



03-FIL32001-A/B-D150 CO_2 Fine Filter
03-FIL32002-A/B-D150 Future CO_2 Fine Filters
04-PU33002-B/C/D/E-D150 Future CO_2 Booster Pumps

04-PU33001-A/B/C-D150 CO_2 Booster Pump
03-VE35004-D150 Barmston Pig Receiver

10-AA31001-D150 CO_2 Metering and Analysis Package
03-EX33001-D150 CO_2 Booster Pumps Recycle Cooler

10-AA34001-A/B-D150 Barmston HIPPS Package
03-VE35005-D150 Barmston Pig Launcher

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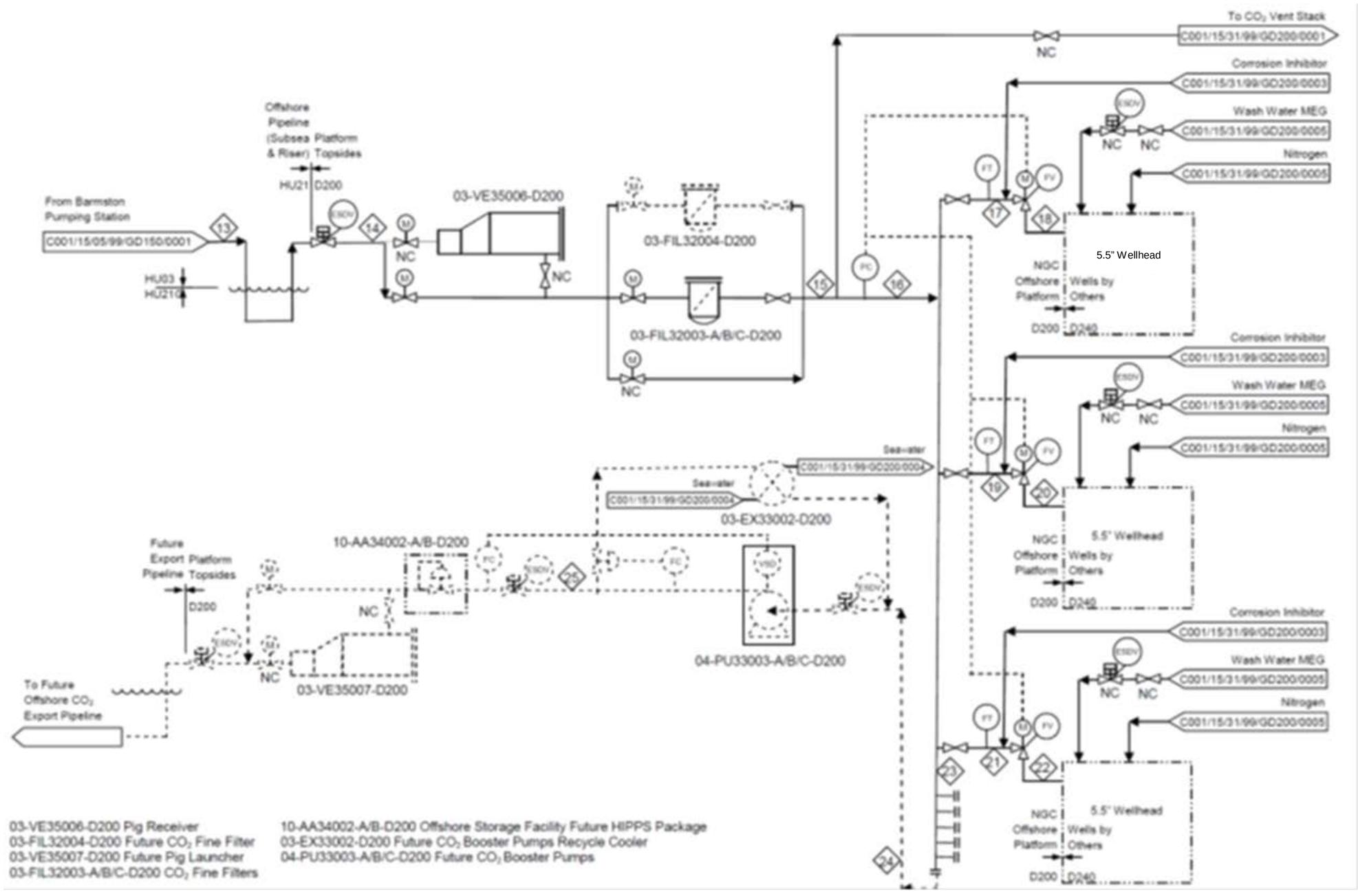
Figure 2.21: Offshore Storage Facility Process Flow Diagram

(T&S Drawing reference: C001/15/05/99/GD200/001)



3 Glossary

Abbreviations	Meaning or Explanation
AG	above ground
AGI	Above Ground Installations
ASU	Air Separation Unit
BAC	Boosted Air Compressor
BFD	Block Flow Diagram
CCS	Carbon Capture and Storage
CCW	Closed Circuit Cooling Water
CEMS	Continuous Emission Monitoring System
CO_2	Carbon Dioxide
CPL	Capture Power Limited
DECC	The UK Government's Department of Energy and Climate Change
Dense Phase	Fluid state that has a viscosity close to a gas while having a density closer to a liquid. Achieved by maintaining the temperature of a gas within a particular range and compressing it above its critical pressure.
ESDV	Emergency Shutdown Valve
ESP	Electrostatic Precipitator
FEED	Front End Engineering Design
FGD	Flue Gas Desulphurisation
GAN	Gaseous Nitrogen
GAP	Gaseous Air (Pressurised)
GE	General Electric
GGH	Gas to Gas Heater
GOX	Gaseous Oxygen
GPU	Gas Processing Unit – processes the flue gases to provide the dense phase carbon dioxide
HIPPS	High Integrity Pressure Protection System
HP	High Pressure
IP	Intermediate Pressure
KKD	Key Knowledge Deliverable
LFO	Light Fuel Oil
LIN	Liquid Nitrogen
LOX	Liquid Oxygen
LP	Low Pressure
MAC	Main Air Compressor
MCW	Main Cooling Water
MEG	Monoethylene Glycol
MP	Medium Pressure
MW	Megawatt
N_2	Nitrogen
NaOH	Sodium Hydroxide
NC	Normally Closed
NGC	National Grid Carbon Limited
NH_3	Ammonia

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Abbreviations	Meaning or Explanation
NNF	Normally No Flow
O_2	Oxygen
OPP	Oxy Power Plant
PFD	Process Flow Diagram
PIG	Pipeline Inspection Gauge: a unit, which is inserted into the pipeline, to clean and/or monitor the inner bore surface of the pipe.
SCR	Selective Catalytic Reactor
SO_3	Sulphur Trioxide
TP	Terminal Point
T&S	Transportation and Storage
UG	underground
VSD	Variable Speed Drive
WR	White Rose

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