Christmas Tree Systems

- Onshore tree
- Offshore tree
- Subsea tree
Goals

- Know the purpose and basic functions of a XT
- Understand the main concept types of XT
- Know the main building blocks of a XT

Xmas Tree Systems

This module will cover:
- Main codes for XT equipment
- XT principles and functions
- Typical schematic
- Main types
- Building blocks
  - Valves, main principles
  - Chokes, main principles
  - Tree Connector
  - Tubing Hanger
- Control system and monitoring
**Applicable codes and standards**

Main codes for XT Equipment:
- API 6A/ISO 10423 Specification for Wellhead and Christmas Tree Equipment
- API 17D/ISO 13628-4 Subsea wellhead and tree equipment
- ISO 13628-1 General Requirements and recommendations
- ISO 13628-6 Subsea Production control System
- API 16A / ISO 13533 Specification for Drill-through Equipment
- + ASME, ISO, BS

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**Purpose of a XT**

- The purpose of a **production** Xmas Tree is to control the flow of hydrocarbons from its respective well via various control valves and choke, to receiving unit. This can be a fixed or floating vessel or produced via pipeline to shore.
- The purpose of an **injection** Xmas Tree is to control the flow of water or gas into its respective well via various control valves and choke, from a process installation off- or onshore.
**XT functions**

Xmas Tree Functions:
- Safety barrier
- Safely stop produced or injected fluid
- Injection of chemicals to well or flowline
- Allow for control of downhole valves
- Allow for electrical signals to downhole gauges
- To bleed of excessive pressure from annulus
- Regulate fluid flow through a choke (not mandatory)
- Allow for well intervention

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**XT schematics**

XT Schematic
- PMV Production Master Valve
- PWV Production Wing Valve
- AMV Annulus Master Valve
- AWV Annulus Wing Valve
- ACV Annulus Circulation Valve
- XOV Cross Over Valve
- SCSSV Surface Controlled Subsurface Safety Valve
- PTT Pressure/Temperature Transmitter

![XT Schematic Diagram](image-url)
Xmas Trees – Main types

Two main types of subsea trees are used in modern offshore technology:

1. Horizontal XT
2. Dual Bore tree (Conventional / Vertical XT)

<table>
<thead>
<tr>
<th>Horizontal tree</th>
<th>Vertical tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production master valve (PMV) in horizontal bore</td>
<td>Production master valve (PMV) in vertical bore</td>
</tr>
<tr>
<td>Single, concentric bore</td>
<td>Dual bore (production + annulus)</td>
</tr>
<tr>
<td>Production bore up to 7”</td>
<td>Production bore up to 5”</td>
</tr>
<tr>
<td>Must pull the production tubing to retrieve the tree</td>
<td>Must pull the tree to retrieve the production tubing</td>
</tr>
<tr>
<td>Workover riser on tree</td>
<td>Requires landing string to secure well before workover</td>
</tr>
<tr>
<td>Both barriers fail if the tree is accidentally removed</td>
<td>Primary barrier is maintained if the tree is accidentally removed</td>
</tr>
<tr>
<td>Designed to take the load from a BOP (increased weight)</td>
<td>Not designed to take the load from a BOP</td>
</tr>
<tr>
<td>Must run the BOP twice during completion</td>
<td>Only needs one BOP run during completion</td>
</tr>
</tbody>
</table>
Xmas Trees – Main types

It is not the intention to advocate the other concept compared to the other here.

- Horizontal trees have gained popularity in Norwegian waters for the past 15 years. This is mainly due to the complex reservoir structure, which promote a solution for easy access to heavy workover and subsequent production tubing retrieval.
- Probably the most important selection criteria is the HXT possibility to accommodate 7” production tubing, whilst the conventional tree hardly accommodate larger than nominal 5”.
- Recent field developments where simultaneously gas injection/oil production are required have been with conventional trees.

Xmas Trees – Main types

Other concepts may be introduced in order to meet new requirements, e.g. when going to large bore > 7” through bore, or light weight trees.

See ISO 13628-4 for other concepts.

Single bore tree

1. Production master valve
2. Tubing hanger
3. Annulus/service line (optional)
4. Annulus valves
5. Tubing spool
6. Production line
7. Mudline suspension wellhead
Xmas Tree Valves

The Xmas Tree assembly contains the following valves:

- Production (or Injection) valves (typ. 5-7” gate valves) for controlling the process medium
- Annulus (or Injection) valves (typ. 2” gate valves) for annulus access.
- Service valves (typ. 3/8” to 1”) for chemical injection.
- Isolation valves (typ. 3/8” to 1”) for pressure test and downhole lines
- Check Valves (typ. ½-1”) for preventing back-flow of well fluid to service lines

Xmas Tree Gate Valves
Xmas Tree Gate Valves

Valve principles

- Valve Product Verification testing in principle described in API 6A with additions in API 17D. Pay attention to pressure classification and verification to max/min pressures at rated sea water depth.
- According to standards, valve and actuators can be qualified separately. However, the simplest way of actuating the valve in the test is often by using the dedicated actuator.
- Principles, pressures, force balance, seawater depth effects, see previous slide.
- Do not forget that Subsea Production Control Codes may influence your valve/actuator design parameters.

Subsea Production Chokes

- The choke is used to control the production rate and downstream pressure from the well. The subsea choke is located on the XT, or as with recent projects, on a ‘choke bridge’ on the template.
- In both scenarios, downstream the PWV.
**Subsea Production Chokes**

Different concepts exist:
See ISO 13628-4 for main principles

- 3 Major suppliers
  - Cameron Willis
  - Master Flo
  - Kent Introl

- Other suppliers of similar equipment not currently serving the subsea business area:
  - Mokveld
  - Hydril
  - Wood Group Pressure Control
  - N-Line

Figure 10 — Choke casing outer configurations
Subsea Production Chokes

- In addition to the different concepts shown on previous slide, the following classification can be given
  - Positive chokes
  - Adjustable chokes
  - Subsea retrieval chokes
  - Non retrievable chokes

- The trend in the choke industry has changed from having focus on erosive wear resistant design to be more robust for vibration and foreign objects
**Xmas Tree Connectors**

The tree connector is the element that allows the tree to be installed and securely connected to the wellhead.

Normal requirements are:

- 25% increased capacity to unlock compared to lock
- Mechanical lockdown function (both on hydraulic and mechanical connectors)

The hydraulic connector are getting its hydraulic pressure from WOCS through the TRT.

The mechanical connector are mechanically functioned through the TRT.

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**Tubing Hanger**

- The TH have its own lockdown mechanism, with additional mechanical lockdown functions.
- To save one trip and therefore also rig time is today's trees often equipped with a combined Tree Cap / Tubing Hanger. The TH then provides two set of lockdown profiles internally for plugs.
- Safe setting of ITC have been troublesome
- Normally a pup pieces is installed onto the Tubing Hanger. This pup is normally CPI and the threaded connector type are controlled through contract or project interface.
Tubing Hanger

- From ISO 13628-4

![Diagram of Tubing Hanger](image1)

- From ISO 13628-4

![Diagram of Tubing Hanger](image2)
**XT control system and monitoring**

- In modern offshore technology, the XT is remotely operated through a multiplex system. This means, through modern power and signal technology the production is continuously monitored with pressure and temperature as well as valve actuation and status are given/monitored by the PCS.

  - Pressure and temperature sensors are installed in production flow, upstream and downstream choke and on the annulus. XT also provides possibilities to monitor pressure and temperature down in the production tubing.
  - Pressure and temperature sensors are often duplicated for redundancy.
  - Modern fields are often designed with sand and/or erosion probes to detect sand production or erosion in system.
  - Multiphase flow meters are getting more common in the industry.

**Buzz group**

Two by two:
- Use the drawing of the XT and describe the functionality using the terminology just presented... (10 min)
- Do you have any questions? Clarify in plenary!
Christmas Tree (XT) Systems

Key takeaways:

- The purpose of a XT
- Functions of a XT
- Different XT concepts
- XT building blocks