



Separation internals: Field Installation and Inspection To Enable The Potential For Good Performance

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Presenter



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Abstract



- The process design of a separator many times requires solutions with a number of complex separation internals, which combined will provide the desired process performance. Even with the best designs, if the separation internals are not fabricated according to the defined requirements, do not fit in the vessel correctly, or even worse, are not properly installed, all the process design efforts are worthless.
- Field installation and inspection verification of internals is a critical step. This presentation has the goal to describe how a proper factory inspection and field installation of the separation internals needs to be carried out. The installation and inspection must address the key issues that might occur to avoid poor separator performance.



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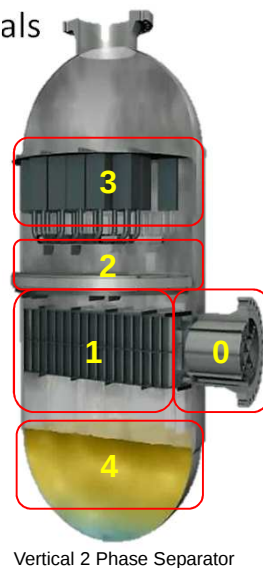
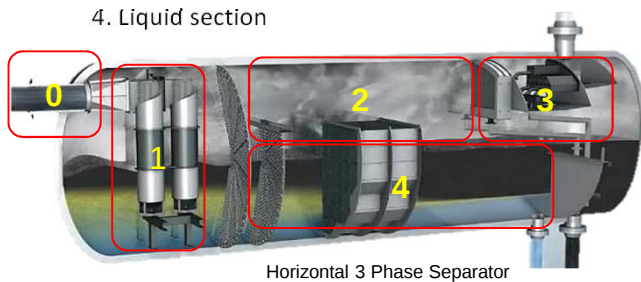
Fundamentals of Separation



Separator with High Efficiency Internals

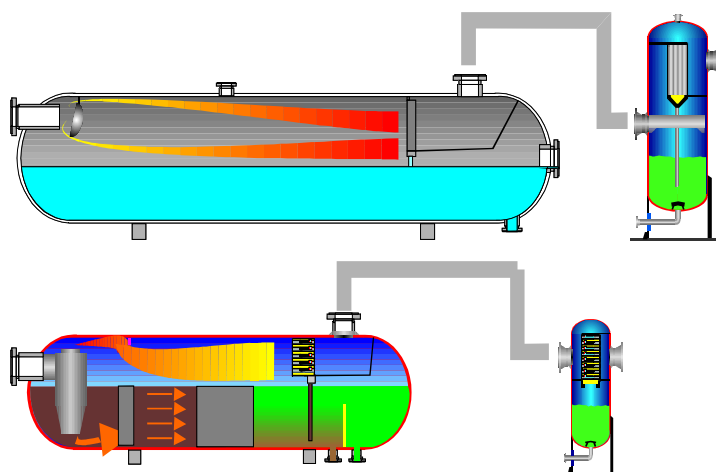
Carry out the fluid phase separation in an efficient way, internals improves the separation efficiency.

- 0. Upstream piping and inlet nozzle
- 1. Vessel inlet section
- 2. Gas simple gravity section
- 3. Mist elimination section
- 4. Liquid section

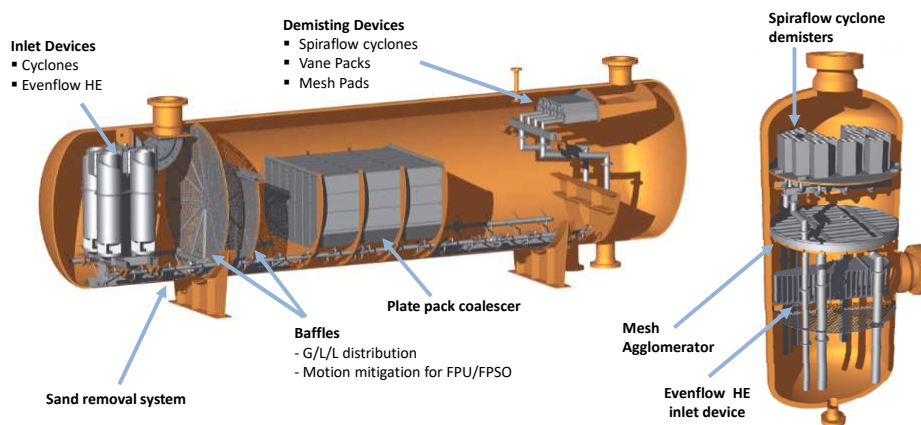


Separation internals: what is the advantage?

Important reductions on vessels sizes and weights when separator internals are properly designed

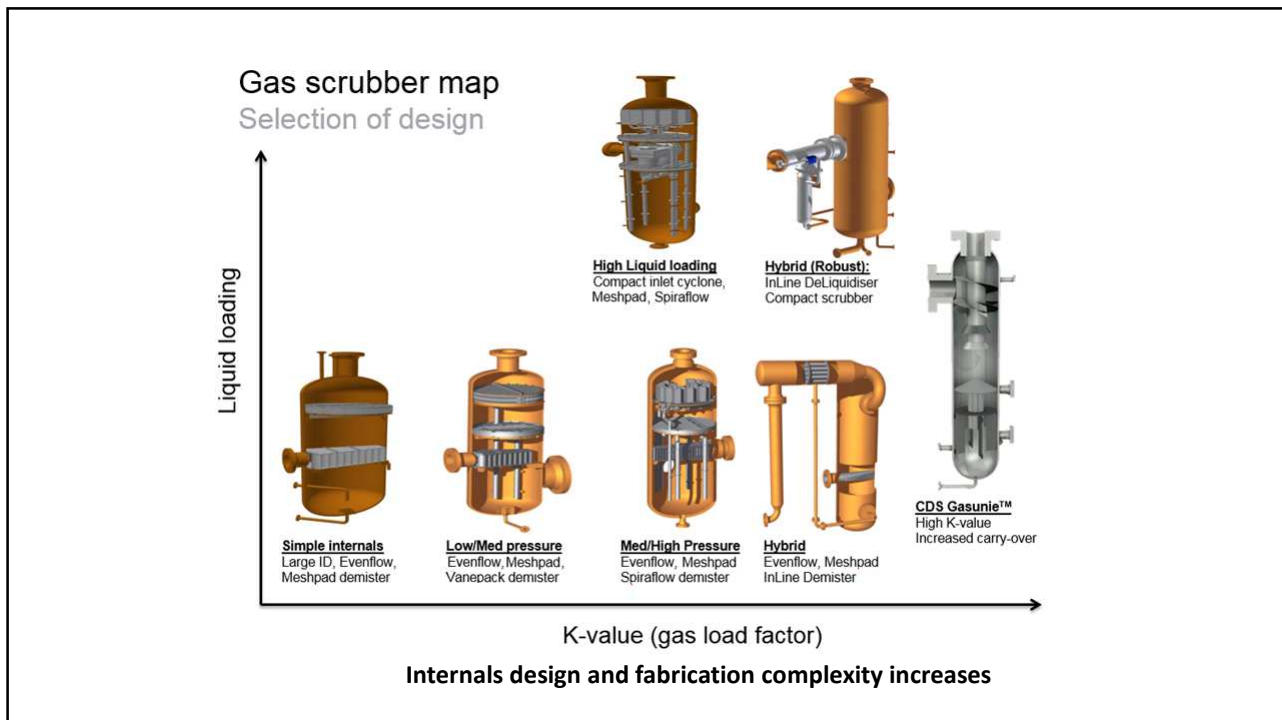


Separator Internals



Selection of Design

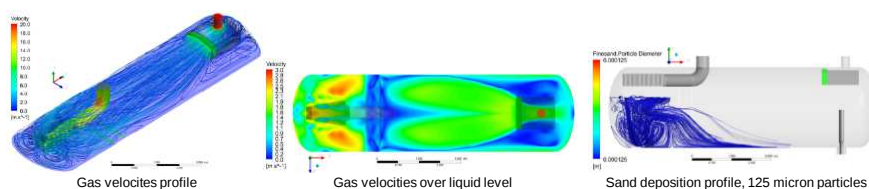




Combination of CFD and FEA

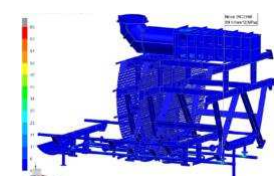
Computational Fluid Dynamics (CFD) used to evaluate performance of the proposed solution. Areas analyzed:

Gas flow & liquid flow distribution within the separator (guarantee supports do not interfere with flow distribution)

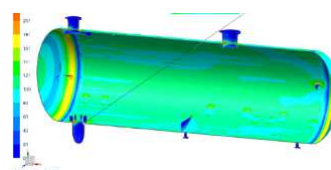


Combination of CFD and FEA

FEA (Finite Element Analysis) used to verify mechanical integrity of the internals and retrofit supporting structure.
Retrofit solutions without the need of welding on vessel walls.



Stresses in Evenflow HE + Vessel Desander



Stresses in the vessel and supports



Factory Inspection

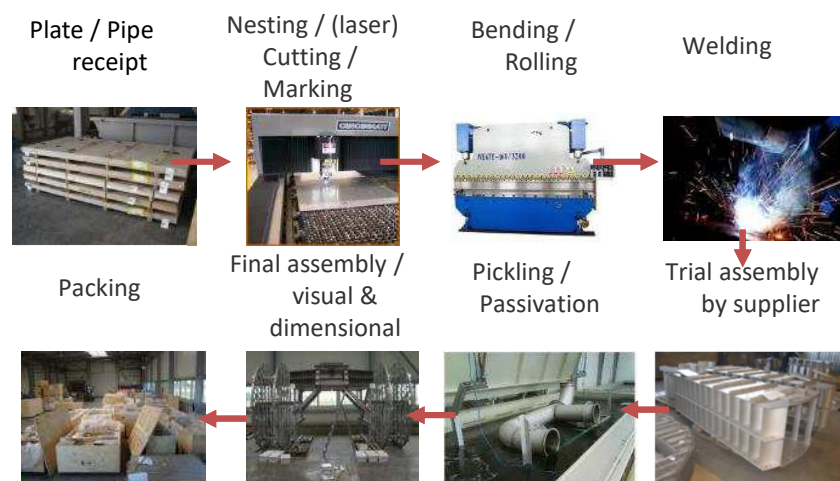


Transforming good process design on real life products

- Internals design complexity increases on challenging geometries.
- Fabrication demanding highly specialized professionals and processes.
- Special stainless steel materials are more often required due to highly corrosive environments.

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Fabrication sequence



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Inspection sequence

- **Toolbox**
 - Contents of the toolbox are HSE regulation / procedures / scope of work / Stop Work Policy.
- **Document verification**
 - Availability of drawings
 - Inspection and test plan (ITP) shall be verified
 - Non-destructive testing (NDT) procedures
 - Commonly used: penetrant testing (PT) on welds and positive material identification (PMI) on materials
 - Material Certificates
 - Confirm the correct material properties are present, ex: 316L or UNS32750
 - Inspection Check List (ICL) shall be available and signed off.
- **Dimensional verification**
 - Main dimensions and interface dimensions on approved drawings.

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Inspection and test plan

- Clearly identify the inspection steps, owners and its responsibility in the activity.



TechnipFMC Project No.:
TechnipFMC Doc. No.:
Client Document Number:
Revision:

INSPECTION & TEST PLAN (VESSEL INTERNALS)				TechnipFMC	Client	Third Party	TechnipFMC Supplier
No.	Activity	Procedure	Acceptance Criteria	Verification Documentation			
Engineering							
1	Review of Client purchase order and project specifications	FMC-PRO-2.1	Check Client purchase order against TechnipFMC bid doc. no. + rev.no. including Commission and/or deviation list	TechnipFMC order acknowledgement	H	-	
2	Project kick-off meeting with client		Client purchase order	Mutual signed minutes of meeting	H	H	
3	Submission of initial project documentation: Supplier Master Document List, Inspection & Test Plan, Engineering & Production Schedule, Manufacturing Record Book Index		Refer to client PO and/or project specifications containing project documentation requirements	Approved initial project documentation	A	A	
4	Process design calculations	FMC-PRO-2.4		Approved process design calculations	A	A	
5	Process design verification by means of computational fluid dynamics (CFD)	Approved Computational Fluid Dynamics (CFD) Procedure		Computational Fluid Dynamics (CFD) Report	A	R	
6	(Process general) arrangement drawings and installation & maintenance manuals	FMC-PRO-2.4	TechnipFMC mechanical design practice	(Process general) arrangement drawings and installation & maintenance manuals	A	A	
7	Fabrication drawings	FMC-PRO-2.4	* Approved arrangement drawings * TechnipFMC mechanical Design Practice	'Issued for construction' fabrication drawings	A		
All documentation / drawings listed under 'Engineering' shall be approved prior to fabrication.							
Fabrication & Inspection							
8	Purchase order to TechnipFMC supplier(s)	FMC-PRO-2.3	* TechnipFMC approved vendor list * Project specifications	Sub-order acknowledgement	H		H
9	Submital of drawings to TechnipFMC supplier(s)		* TechnipFMC sub-order * TechnipFMC Purchase Order to Supplier * Project specifications	Arrangement drawings and 'Issued for construction' fabrication drawings	R		M
10	Sub-order placements by TechnipFMC supplier(s)			Sub-order acknowledgements	M		M
11	Receipt of materials Main materials	Incoming Goods Procedure	* Material grade: 316L * Type 3.1 certificates according to EN 10204 * Steel materials to comply with NACE MR01-75 (ISO 15156-3) requirements	Material Test Certificates P17-02303-4847-001	A	R	H
	Bolting		* Bolting grade: 316 * Bolt: ASTM A193 Gr. B8M * Nut: ASTM A194 Gr. B8M * Type of thread * Metric according to ISO 724 * Dimensions: - Bolt: DIN 69150/ISO 4017 (full threaded length) - (Bolt) Washer: DIN 9021/ISO 7083 & DIN 125/ISO 7089 - Nut: DIN 934/ISO 4032 * Type 3.1 certificates according to EN 10204				

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Material Certificate

- Confirm material chemical compositions
- Normally EN 10204 3.1 type of certificates
- 316/316L/UNS32750 type of materials
- NACE MR-0175
- Heat numbers
- Dimensions

outokumpu CERTIFICATE - ZERTIFIKAT

EN 10204-3.1
2205041 DN
01-04-2015

Product: **Plate**
Material: **316L**
Thickness: **10mm**
Width: **1500mm**
Length: **2000mm**

Heat number: **316L**
Lot number: **316L**

Chemical composition (EN 10204-3.1):

Element	Content (%)
C	0.025
Mn	0.035
P	0.015
S	0.005
Si	0.045
Cr	16.50
Ni	10.50
Mo	2.00
Cu	0.010
Al	0.010
Fe	Balance

Dimensions (mm):

Dimension	Value
Thickness	10
Width	1500
Length	2000

Signature: *[Signature]*

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Inspection sequence at factory shop

- Visual verification
 - Welds properly cleaned after pickling and passivation (no discoloration)
 - Avoid corrosion related to oxidation from the weld process
 - No weld spatters present and no weld defects.
 - Avoid corrosion related to the weld poor quality
 - Sharp edges removed.
 - Alignment of bolt holes.
 - Verification of marking, are all item numbers available as listed on the drawings.
 - Bolting available as per latest revision drawings.

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Internals Factory Assembly

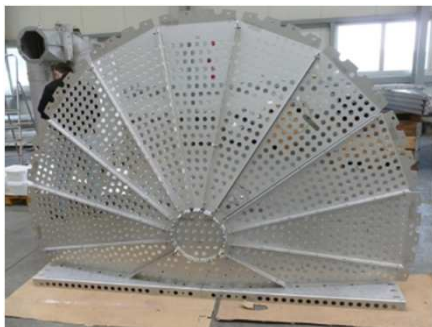
After all parts are fabricated, it is critical to carry out a factory assembly to confirm all items are available, for the final inspection process.

Inlet cyclones ready for final inspection



Internals Factory Assembly

Baffles ready for final inspection



Internals Factory Assembly

Evenflow ready for final inspection



Sandjet ready for final inspection



Internals factory marking, numbering, heat numbers

For projects with multiple vessels, it is recommended to color paint the parts that are related to a specific vessel tag number, avoiding this way materials to be installed on incorrect vessels.



Internals Factory marking, numbering, heat numbers

All parts are marked with unique numbers that need to match with engineering drawings, which will support field service teams during installation.



Internals factory marking, numbering, heat numbers

A **heat number** is an identification coupon **number** that is stamped on a **material** plate after it is removed from the steel mill. All our plate materials have engraved heat numbers, for traceability purposes on material certificates.



Welding requirements and cleaning

- Separation internals are not classed as pressure containing equipment, therefore, the welds need to guarantee the structural stability of the internals only.
- Fabrication normally follows ASME IX or ISO 15614 specifications, unless specific requirements are defined by client.
- Surface conditioning of welds by grinding or brushing may be necessary to achieve a specified contour to minimize stress raisers, may also be necessary to prepare the surface for pickling and passivation, coatings or to facilitate subsequent non-destructive examination and avoid corrosion issues.

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Welding requirements and cleaning

Cleaning methods:

1. By means of **Mechanical**: brushing, blasting and grinding:
Spatters and heat tint
2. By means of **Chemical**: Pickling and passivation:
Heat tint and Oxide scale

Pickling:

Pickling normally involves using an acid mixture containing 8-20 vol% nitric acid (HNO_3) and 0.5-5 vol% hydrofluoric acid (HF).

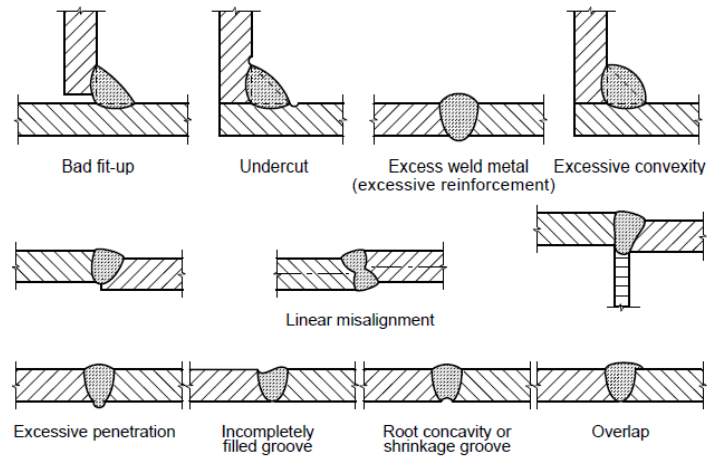
Passivation:

This procedure is carried out in a manner similar to pickling, but in this case the active agent is nitric acid only, 18-30 weight % at around 20°C.

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Visual inspection for good welds quality

Most common (visual) weld defects according to ISO 5817



Visual inspection for good welds quality

Important to verify the welds for discoloration, which is a sign of lack of cleaning – pickling and passivation, which could generate a risk for future corrosion in the part.

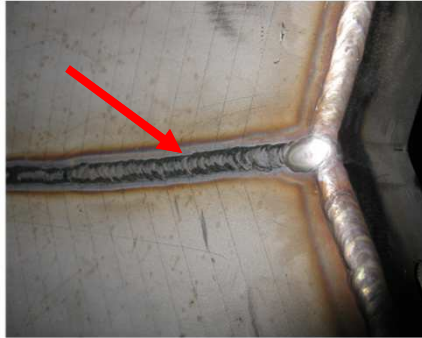


Discoloration (lack of pickling and passivation)



Part after pickling and passivation

Visual inspection for good welds quality



Weld discoloration



Weld properly filled and cleaned

Visual inspection for good welds quality



Discoloration (lack of pickling and passivation)



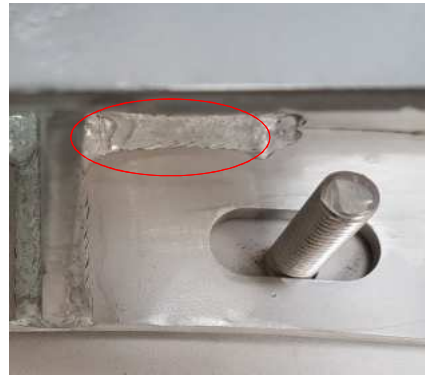
Part after pickling and passivation

Visual inspection for good welds quality

Weld defects are normally easy to be spotted visually, and they can compromise the part structural behavior defined by design.



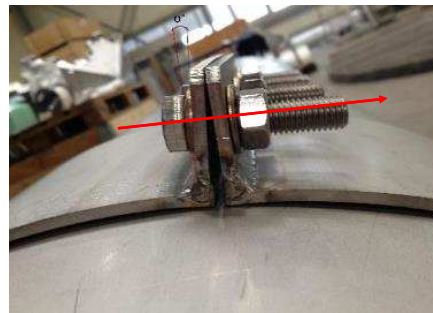
Weld defect (incomplete filled groove)



Weld properly filled groove

Bolting alignment

Due to the fact the internals are designed to fit thru small manways, and fabricated in small pieces a great number of bolting are required to connect the parts, and therefore, it is crucial to verify during the final inspection the alignment of bolt holes.



Dimensional check

Main dimensions and interface dimensions as listed in the drawings shall be verified. Measured dimensions shall be recorded during the final inspection.



Dimensional check

The dimensional check is important to avoid parts do not fit properly during installation. In this case a clip with incorrect dimensions had to be modified on site to properly connect one of the internal section, in this case a meshpad.



Bolting and gaskets check

Check bolting and gaskets are available as per latest drawings and packing lists.



Bolting prior to packing



Gaskets prior to packing



Trial-fit on factory shop



Simulating site conditions on factory shop

- Fabrication of a “dummy-vessel” with the same dimensions of the site vessel.
- Confirm the internals can fit thru the manway.
- Training of client crew of the installation of the internals in a “stress free” environment.
- Checking of the interface dimensions between vessels support and internals.

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Mock-up horizontal vessel on factory shop



Horizontal vessel (304 stainless steel material)



Parts accessibility (fit) thru manway

Mock-up horizontal vessel on factory shop



Support beams inside of the vessel

Mock-up horizontal vessel on factory shop



Internals installed inside of the vessel

Mock-up vertical vessel on factory shop

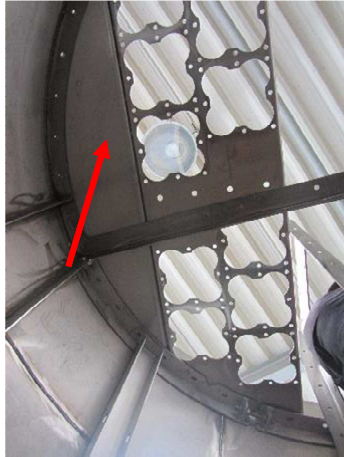


Mock-up vertical vessel on factory shop



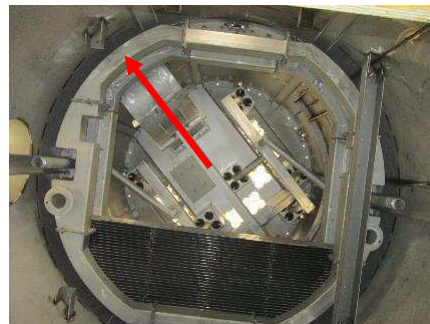
Installation of Support structures vertical vessel

Mock-up vertical vessel on factory shop



Installation of spiraflo decks – vertical vessel

Mock-up vertical vessel on factory shop



Installation vanepack assembly – vertical vessel



Field Installation



Field installation: where should I start ?

- An installation for a typical internals project can comprise of hundreds of different parts and thousands of bolting that will fit in small vessels (confined space)



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Field installation: where should I start ?

- Basic steps to carry out a successful installation:
 - unpack the goods per section to be installed, for example: inlet cyclone, baffles and meshpads.
 - count the parts, bolting and gaskets and check against drawings and packing list.
 - lubricate the bolting
 - Isolate the area to avoid other crew to interfere in the job
 - position the parts in a logic way, that will facilitate the installation inside the vessel.



Spiraflo deck positioned – ready to be installed in the vessel

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Hazards of confined space work

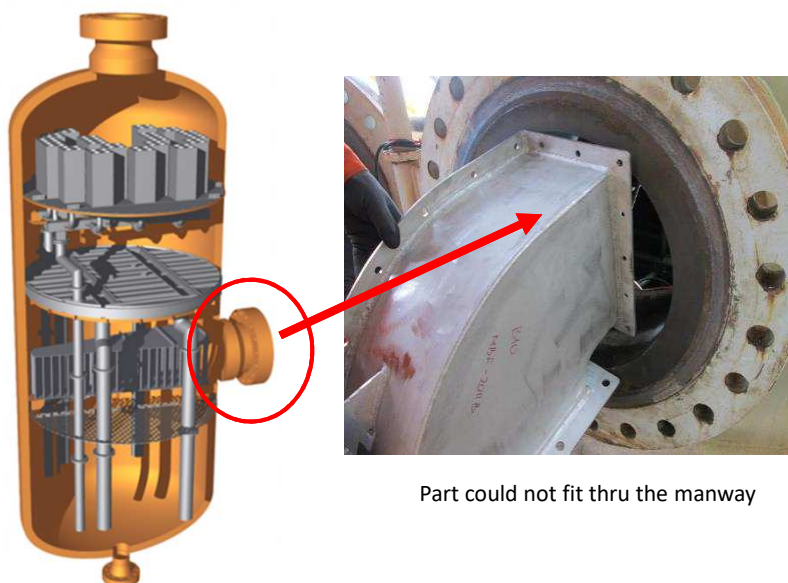


Safety tips for working at confined space

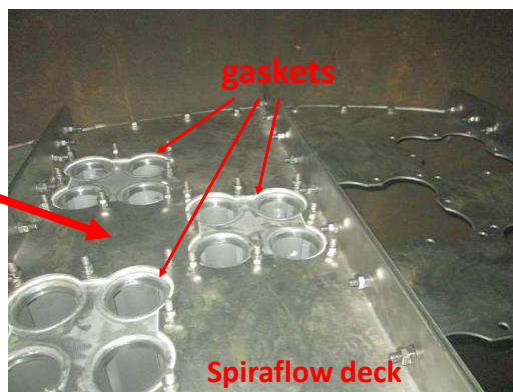
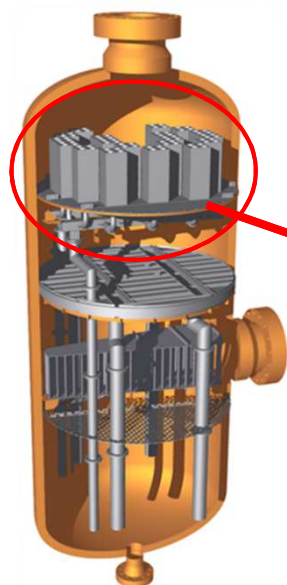
- Relevant training
 - Confined space (watch or supervisor) and working at heights.
- Work permit clearance
 - Manway watch
 - Ventilation
- Proper isolation philosophy
 - Make sure the vessel inlets and outlets are physically blocked before vessel entry (spectacle blinds), if possible check the PID and identify the blocking positions yourself and discuss with local safety team.
- Cleaning and venting of the vessel
 - Make sure the correct cleaning procedure is used (purging for example).
Venting for 24 hours, maybe more.
- Personal Protection Equipment (PPE)
 - Autonomous breathing equipment, gas check (O₂ at 21,4%), safety harness.

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Field installation– importance of correct dimensions

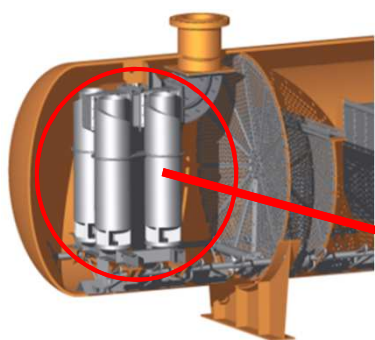


Field Installation - Sealing of chambers – clean gas



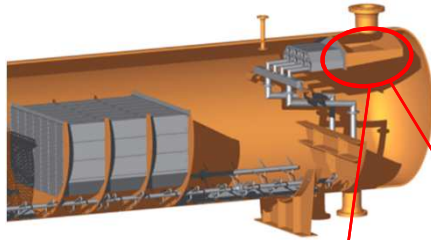
Very important to apply the gaskets on the correct sections, to avoid gas by pass between chambers.

Field Installation - Sealing of inlet cyclones – excessive torque



Excessive torque will damage the gaskets causing, which could cause a lack of sealing

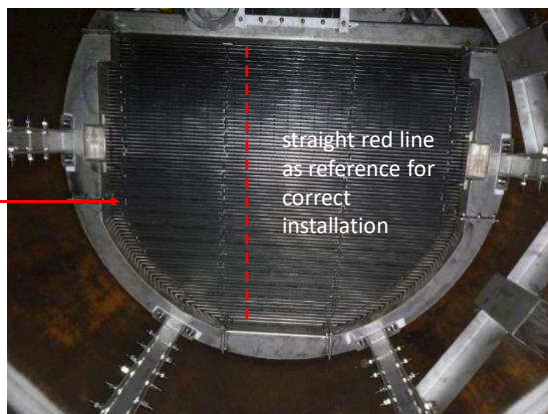
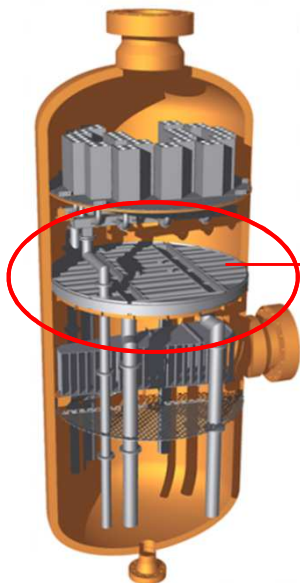
Field Installation - Correct sealing of gas boxes



Gas boxes need to be sealed to avoid contamination of cleaned gas. The sealing is carried out by proper installation of the gaskets.

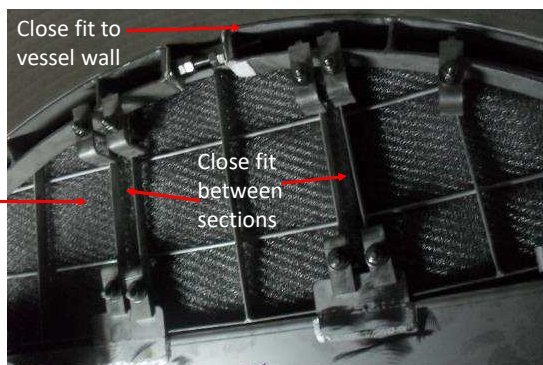
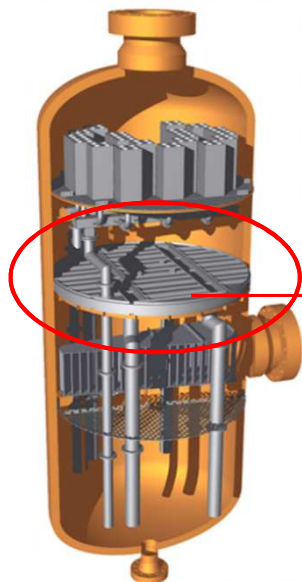


Field Installation - Correct alignment of vane pack coalescers



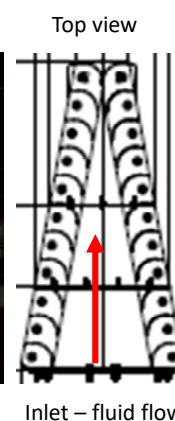
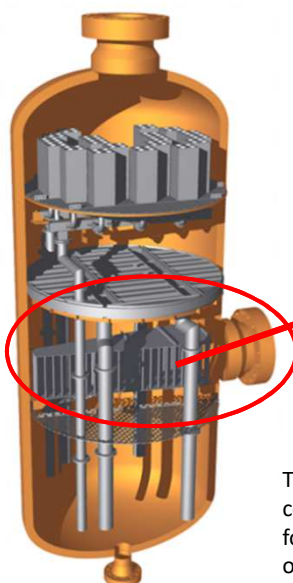
The vane pack plates need to be installed in parallel within each other in the casing, to avoid flow distribution issues.

Field Installation – meshpad correct installation



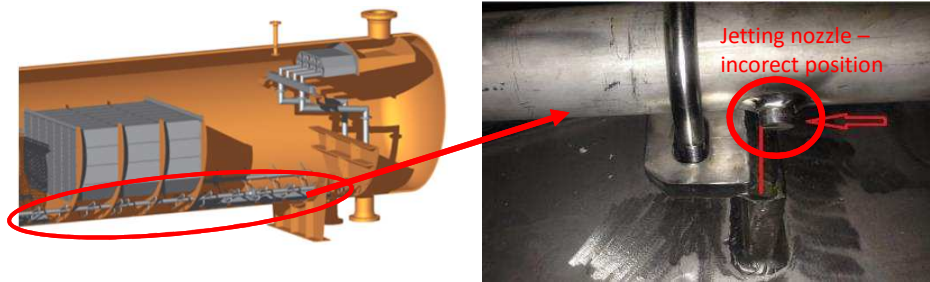
The installation of meshpads requires attention to close fit the mesh grid to vessel wall and between sections, use of flashlight to check that there are no gaps, could be a practical way of checking it.

Field Installation - Correct installation of inlet devices – vane ladders and bolting



The evenflow needs to be installed in the correct position (angle) of the vane ladders, for good flow distribution. Bolting end to the outside.

Field Installation - Correct installation for sandjet system – jetting nozzles



Jetting nozzles need to be clear of obstacles to be able to spray the water in the designed angles.

Field Installation - Properly secure bolts with double nuts

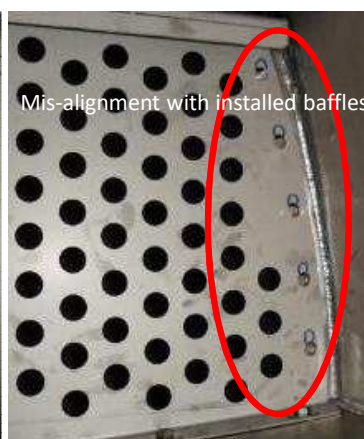


The structural assurance of the design considers fixation of the internals with double nuts, and due to the amount of bolting involved is quite common to have bolts without double nuts or incorrect size bolting installed.

Field Installation - Properly secure bolts with double nuts



Field Installation - Interface support with correct sizing



The design of internals, in a retrofit or new built project, considers the interface between the supports and the designed parts, if the supports are not within the correct dimensions, the installation might be under jeopardy.

Field Installation - After work is done – care for a clean vessel



The amount of work involved to install internals on confined space, requires a lot of tools, parts, bolting and multiple crews, and therefore, there is always a risk of tools, wraps or other leftovers, been forgot inside of the vessel after the work is done. It is crucial to check the cleanliness of the vessel before its closure.



Conclusions and Recommendations



Conclusions and recommendations

- Based on the exposed in this presentation it is quite clear that, after the process design definition, there is quite a lot of work to transform the ideas in a real life product and operational solution.
- Special parts geometries, impose a challenge to mechanical engineering design, fabrication and installation of separation internals.
- For the fabrication phase it is important to assure that materials are per specification (material certificates, PMI), dimensions are according to the design, a good weld quality is in place.

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Conclusions and recommendations

- For the installation phase, attention to sealing of chambers (good installation of gaskets), bolting secure with double nuts, parts installed as design and installation manual.
- Working safely on confined space, which requires a lot of preparation before vessel entry, even if you are the most experienced person when working in confined space, never neglect the hazardous of this special working environment.
- I hope the information provided in this session gave a good hint on fabrication, inspection and installation of separation internals and its importance on the overall solution to client success.

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THANK YOU
Q&A SESSION

