VRV Group:

VRV
VRV S.p.A.
Ornago (MB) - Italy
+39 039 60251
commercial@vrv.com

VRV ASIA
VRV India Cryogenic Equipment Pvt Ltd.
Chennai - India
+91 8623304700
cryo@vrv.com

VRV SERVICES
VRV SERVICES S.r.l.
Ornago (MB) – Italy
+39 039 60251
cryo@vrv.com

CRYO DIFFUSION
Cryo Diffusion S.A.
Léry - France
+33 2 32590368
info@cryodiffusion.fr

FEMA
FEMA S.r.l.
Rho (MI) - Italy
+39 02 9302900
info@femasrl.it

www.vrv.com

Preview October 2010

Energy & Petrochemical Division

Committed to a better future …

VRV S.p.A.

VRV S.p.A. is an international industrial company established in 1956 and operating in the design and manufacture of pressure equipment for the chemical, petrochemical, power and cryogenic industries. It is organized into three different divisions: the Energy and Petrochemical Division, the Process and Equipment Division and the Cryogenic Division.

This brochure shows the evolution, planning and technological improvement achieved by VRV S.p.A. in the traditional manufacturing activity of quality pressure vessels.

This evolution has enabled the Company to manufacture sophisticated equipment, up to the supply of turnkey industrial plants over the years.

The various products manufactured by VRV - reactors, columns, heat exchangers, special vessels, drying and granulation plants, polysilicon production plants, cryogenic equipment - are illustrated through technical descriptions and photographic documentation.
This is in line with the company principle of continuous technological improvement within a widely diversified product range.

Refining

Petrochemical

Fertilizer

Process

Cryogenic

Research & Development

Refining

VRV exhibits a wide range of tailor-made designs for critical equipment destined to refining applications and gas cracker plants.

VRV production range mainly focuses on high pressure / high temperature heavy wall reactors like hydro-crackers, HDT & HDS reactors, CCR platforming reactors, regenerators, high pressure heat exchangers.

In addition, VRV can offer a complete set of engineering services, including Thermal Design (HTRI / HTFS), Mechanical Design and Finite Element analysis (ANSYS) and detailed Flow Induced Vibrations analysis (FIV) and Advanced Pressure Vessels analysis (APV).

For over 30 years VRV has been providing these components according to the specifications of worldwide recognized licensors like UOP, AXENS, ExxonMobil, Chevron, Lummus in compliance with design codes: ASME VIII Div.1 & 2, AD 2000, PD 5500 and CODAP.

Hydrotreating Heavy Wall Reactors

VRV features a variety of reactors / separators utilized in the hydrotreating process to remove contaminants such as sulphur, nitrogen, condensed ring aromatics or metals from naphtha feedstocks at elevated temperatures and pressures.
These are manufactured in various grades of low-alloy steels, with wall thickness up to 250 mm, welded by means of our wide experience in narrow gap welding techniques, with pre and post welding controlled procedures. Internal lining can be offered with cladded or overlaid construction, carried out in single-layer or double-layer by ESW or SAW processes.
NDE techniques are TOFD, CB-Scan, Phased Array in accordance with ASME C.C. 2235 instead of RT for heavy wall components.
Reactor internals, generally outsourced, may also be assembled in reactors as per customer's requirements.

Our production range capacities for reactors are:

Weight	up to 500 ton
Length:	up to 50 m
Width:	up to 6,5 m
Thickness:	up to 250 mm

1 HDS Reactor (350 ton), 2.25 Cr alloy w/ 347 SS W.O.,
Foster Wheeler - TOTAL, La Med refinery, France

2 Cracked Gas Dryer (385 ton),
Technip - Yanbu National Petrochemical Co., Yanbu refinery, Saudi Arabia

3 HDS Reactor (385 ton), 2.25 Cr alloy w/ 347 SS W.O.,
ERG Energia, Priolo refinery, Italy

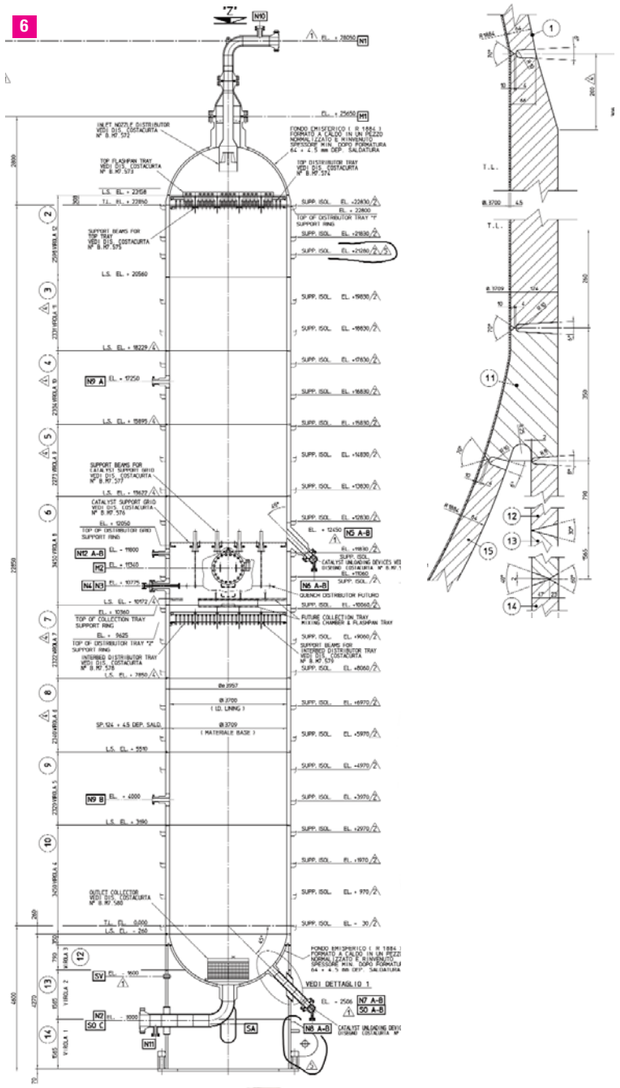
4 HDS Reactor (380 ton), 2.25 Cr w/ 347 SS W.O.,
Reliance, Jamnagar refinery, India

5 HDS Reactor (350 ton), 2.25 Cr alloy w/ 347 SS W.O.,
Foster Wheeler - TOTAL, La Med refinery, France

6 Typical drawing of HDS Reactor

7 HDS Reactor (350 ton), 2.25 Cr alloy w/ 347 SS W.O.,
Foster Wheeler - TOTAL, La Med refinery, France

8 C2 Hydrogenation Reactor, 1.25 Cr alloy,
Technip - Yanbu National Petrochemical Co.,
Yanbu refinery, Saudi Arabia



9 H2S Absorber (190 ton), 1.25 Cr alloy w/ 347 SS W.O.,
Tecnicas Reunidas - Galp Energia, Sines Portugal

10 Waste Water Decomposer (205 ton), SA 302 grade B,
Eurotechnica - Point Lisas Trinidad

11 HDS Reactor (350 ton), 2.25 Cr alloy w/ 347 SS W.O.,
Foster Wheeler - TOTAL, La Med refinery, France

Refining

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High Pressure Heat Exchangers

VRV has several designs for high pressure shell and tube heat exchangers, utilized in the hydrotreating process. Heat exchangers most commonly required are TEMA type, DEU modified (bolted-in construction), however, VRV is also highly qualified to supply other types of heat exchangers with special closures for high pressure applications (packed metallic / fiber, trapezoidal metal / fiber and delta metal closures). Most frequently used materials are various grades of low-alloy steels, high nickel alloys, Incoloy 825, Inconel 625. Materials can be offered in solid, cladded or overlaid construction, carried out in single-layer or double-layer by ESW or SAW processes.
Tube to tubesheet joint is performed with orbital-automatic welding with or without filler metal in one or two layers.
NDE techniques are TOFD, CB-Scan, Phased Array in accordance with ASME C.C. 2235 instead of RT for heavy wall components. One of the largest heat exchangers built by VRV weighed 160 tons with an outside diameter of 3,600 mm and an approximate number of 5,000 tubes.

12 Reactor Feed HHPS Liquid, 2.25 Cr alloy w/ 316 SS W.O., Snamprogetti - Enichem, Taranto Italy

13 Typical drawing of Bolted-in Heat Exchanger

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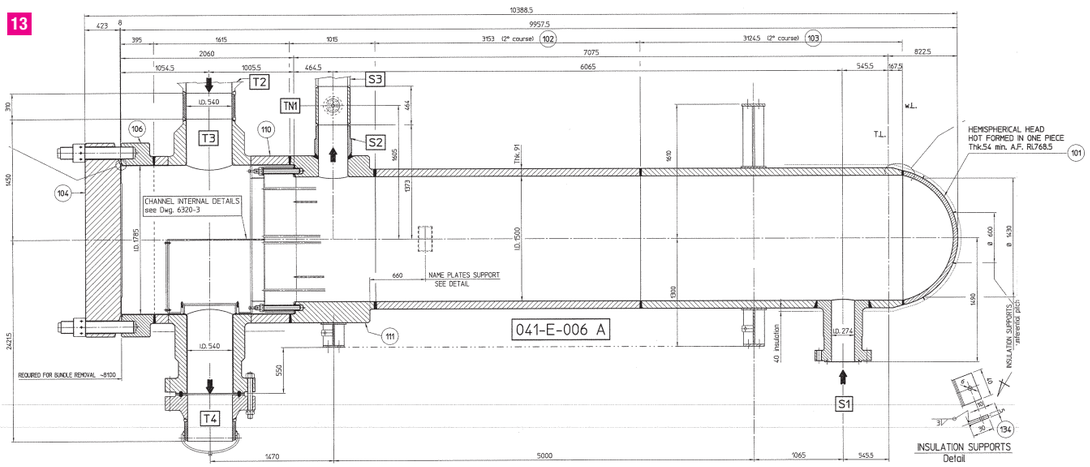

14 Heat Exchanger, SNC Lavalin - Syncrude, Alberta Canada

15 Heat Exchanger, SNC Lavalin - Syncrude, Alberta Canada

16 Preheater Steam Riser (165 ton), 1.25 Cr alloy, Foster Wheeler - Liaoyang Petrochemical Co., China

17 Effluent Feed Exchanger, 2.25 Cr alloy w/ 347 SS W.O., Snamprogetti - SNC Lavalin JV, Fort McMurray Canada

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CCR Components (UOP process)

VRV provides the complete range of main equipment for the UOP's CCR Platforming process, used to convert petroleum refinery naphthas with low octane ratings into high-octane liquid products (gasoline). These are:

- **Platforming Reactor**
- **Regenerator**
- **Feed / Effluent Exchanger (Texas Tower)**

In particular the Platforming Reactor consists of three or four adiabatic, radial-flow sections, arranged in one or more vertical stacks. Catalyst flows vertically by gravity down the stack, while the charge flows radially across the annular catalyst beds. One of the largest Platforming Reactors supplied by VRV was for the Dung Quat refinery in Vietnam, which was 55-meter long and weighed 145-ton.
The partially deactivated catalyst is continually withdrawn from the bottom of the reactor stack and transferred to the Regenerator section. The catalyst flows down through the regenerator where the carbon is burned off and the moisture and chloride levels are adjusted. VRV has supplied Regenerators in 316L SS and Incoloy 825 materials.
The effluent from the last section of the Platforming Reactor runs through the Feed / Effluent Exchanger (Texas Tower) and gives heat to the combined feed (hydrotreated naphtha and recycle hydrogen), which then goes through the fired heaters to reach reaction temperature and be sent to the reactor.


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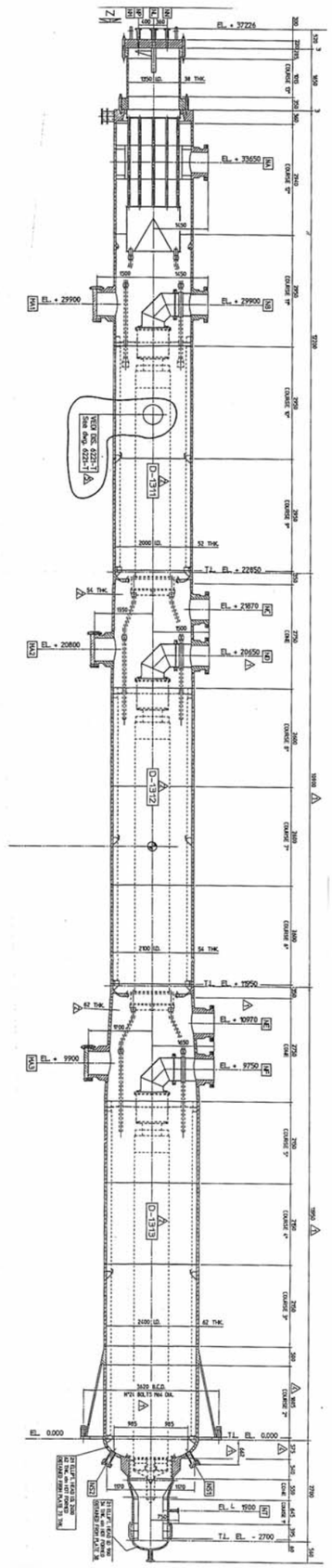
18 Platforming Reactor, 2.25 Cr alloy, Saipem - ENI, Sannazzaro Italy

19 Regeneration Tower, Incoloy 800, Technip - Takreer, UAE

20 Platforming Reactor, 1.25 Cr alloy, Technip - Takreer, UAE



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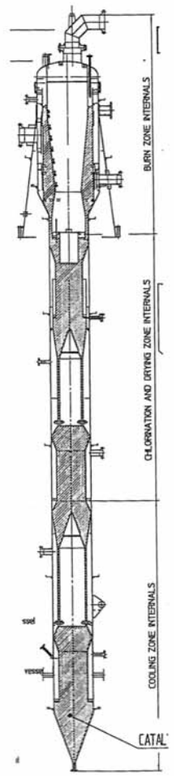

21 Typical drawing of Platforming and Regeneration Tower

22 Platforming Reactor, 2.25 Cr alloy, Saipem - ENI, Sannazzaro Italy

23 Regeneration Tower, Incoloy 800, Technip - Takreer, UAE

24 Powerformed Feed Preheater (Texas Tower) (110 ton), 1.25 Cr alloy, Statoil - Kallundborg refinery, Denmark

25 Platforming Reactor (145 ton), 2.25 Cr alloy, Technip - PetroVietnam, Dung Quat refinery, Vietnam


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CCR Components (AXENS process)

VRV supplies all main pressure vessel components for the Axen's Octanizing process, used to produce high-octane gasoline and hydrogen. These are:

- **Octanizer Reactor**
- **Regenerator**
- **Catalyst Hoppers**
- **Surge Drum**
- **Reduction Chamber**
- **Lift Pots**
- **Washing Drum**

The Octanizer Reactor has a side-by-side arrangement different from the UOP stacked design, with internals consisting of an inner and outer VEE screens. Inside the reactor, the feedstock charge flows radially across the annular catalyst beds, while the catalyst flows vertically downwards by gravity.
The Regenerator has a two-bed stacked construction with flow arrangement similar to the one of the Octanizer. Typical materials of construction are 321 SS and Incoloy 825.
VRV also designs and manufactures the complete set of external pressure vessels for the charge and discharge of the catalyst at the top and the bottom of the Octanizer / Regenerator Reactors. These components are: Catalyst Hoppers, Surge Drum, Reduction Chamber and Lift Pots.
The Washing Drum has the purpose to neutralize burning effluent and comes in contact with highly corrosive products and it requires an internal special lining in Fiber Reinforced Plastic (FRP).

26 Octanizer Reactor, 2.25 Cr alloy,
Sinopec - NIOEC, Shazand Arak refinery, Iran

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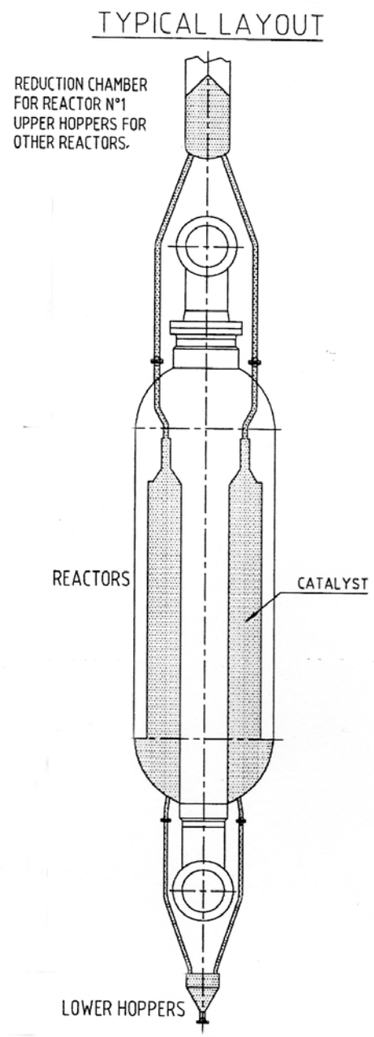

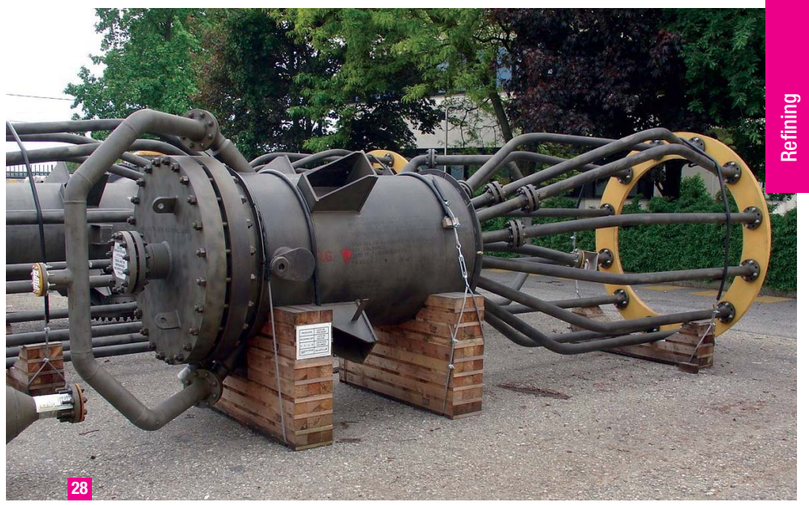

27 Typical Layout of Octanizer Reactor and Hoppers

28 Upper Hoppers, 1.25 Cr alloy,
Namvaran - NIOEC, Esfahan refinery, Iran

29 Hydrotreating Reactor, 2.25 Cr alloy w/ 321 SS clad,
Sinopec - NIOEC, Shazand Arak refinery, Iran

30 Octanizer Reactor, 2.25 Cr alloy,
Sinopec - NIOEC, Shazand Arak refinery, Iran

FCC Components (UOP process)

A Fluid Catalytic Cracking (FCC) unit upgrades heavy distillates from the crude distillation unit into lighter, higher-valued products such as high-octane gasoline, light fuel oils and liquefied petroleum gas.
FCC uses a catalyst in the form of a very fine powder, which flows like a liquid together with heavy feedstock into the base of a vertical sloped pipe called Riser at extremely high temperatures (1,200 to 1,400 degrees Fahrenheit). The hot catalyst vaporizes the feed and facilitates the cracking reactions that break down the heavy hydrocarbons into lighter components.
The catalyst / hydrocarbon mixture flows through the Riser and then is separated by cyclones in a Reactor Separation Vessel. The hydrocarbon stream is then routed to a fractionating column for separation into lighter products such as LPG, gasoline, light gas oil and heavy gas oil.
The used catalyst is sent to a Stripper where it gets in contact with steam to remove any remaining hydrocarbons and then to a regenerator where it gets restored.
VRV offers a range of pressure vessel components for the FCC process:

- FCC Reactor
- Riser Reactor
- Stripper
- Catalyst Cooler

31 Orifice Chamber, CS w/ refractory lining,
JGC Co. - ARAMCO, Rabigh refinery, Saudi Arabia

32 Orifice Chamber, CS w/ refractory lining,
JGC Co. - ARAMCO, Rabigh refinery, Saudi Arabia

33 Catalyst Cooler (79 ton), Ingegneria degli Idrocraburi
Saras, Sarroch Italy

Petrochemical

The VRV product range for Petrochemical applications comprises reactors, vessels, heat exchangers and other equipment with specific focus on high-pressure and high-temperature services.

Major equipment that VRV has supplied includes:

- “Heavy wall” Reactors
- Dehydrogenation Reactors
- Polypropylene and Polyethylene Reactors
- Continuous Polymerization Reactors / Finishers
- High pressure / High temperature Heat Exchangers and Pressure Vessels
- Bayonet-type Heat Exchangers
- Equipment for cryogenic applications

Various materials of fabrication are utilized, ranging from Carbon to Low-Alloy Steel and Austenitic Stainless Steel, from Austenitic-Ferritic Steel to Nickel Alloys (Inconel and Incoloy).

In addition, VRV offers a complete set of engineering services, including Thermal Design (HTRI / HTFS), Mechanical Design and Finite Element analysis (ANSYS) and detailed Flow Induced Vibrations analysis (FIV) and Advanced Pressure Vessels analysis (APV).

VRV equipment is designed and manufactured in accordance with the specifications of worldwide recognized major licensors: UOP, AXENS, ExxonMobil, Chevron, Lummus, INVISTA, Polimeri Europa, Tecnimont, Basell, OMV and Eurotecnica.

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Styrene

Styrene is most commonly produced by the catalytic dehydrogenation of ethylbenzene, which is mixed in the gas phase with 10-15 times its volume in high-temperature steam and passed over a solid catalyst bed.
Commercially significant products include polystyrene, ABS, styrene-butadiene rubber and latex, used in rubber, plastic, insulation, fibreglass, food container and automobile / boat components. VRV is approved by the major styrene process licensors: Polimeri Europa (Snamprogetti), Lummus and Badger.

VRV specializes in the design and manufacture of all main pressure vessel and heat exchanger components of a styrene production plant. These are:

- **Dehydrogenation Reactor** (first stage)
- **Dehydrogenation Reactor** (second stage)
- **Interchanger**
- **Primary Steam Superheater**
- **Re-heater**
- **Main Condenser**
- **LP / LLP Steam Generator**
- **WHE Train**

Typical materials of fabrication are Stainless Steel and High Alloys for high temperature (i.e. 304H and Incoloy 825).

1 Condenser,
Sanmprogetti - NIOEC, Iran

2 Hydrogenation Reactor (155 ton),
Snamprogetti - NIOEC, Iran

3 First & Secondary Reactors, 304H SS & Alloy 800,
Foster Wheeler - Total Petrochemicals, Normandie France

4 Secondary Reactor (325 ton), 304H SS & Alloy 800,
Foster Wheeler - Total Petrochemicals, Normandie France

5 Secondary Reactor (325 ton), 304H SS & Alloy 800,
Foster Wheeler - Total Petrochemicals, Normandie France

Petrochemical

TA / PTA (Invista process)

Terephthalic acid is produced by oxidation of paraxylene by oxygen in air. The oxidation is conducted using acetic acid and a metallized catalyst, composed of cobalt and manganese salts. Impurities are removed by hydrogenation of a hot aqueous solution, which is then cooled to crystallize highly pure terephthalic acid (PTA).
PTA is a commodity chemical, used principally to produce polyester PET to make clothing and plastic bottles.
VRV has developed and supplied several components for PTA production plants worldwide in accordance with the INVISTA license and specification. In particular VRV supplied the following types of equipment:

- Solvent Dehydration Column
- High Pressure Dissolver
- Crystallizer

The Solvent Dehydration Column and the Crystallizer are usually fabricated in solid Duplex Stainless Steel Tp 2205, while the High Pressure Dissolver is fabricated in Low-Alloy Steel, weld overlaid in Stainless Steel Tp 347.

6 Solvent Dehydration Column and Crystallizer, Duplex 2205, Foster Wheeler - Indorama, Map Ta Phut Thailand

7 CTA Crystallizer, Foster Wheeler - Indorama, Map Ta Phut Thailand

8 Dehydration Column, Duplex 2205, AkerKvaerner - Petroquimica Suape, Brazil

Petrochemical

9 CTA Crystallizer, Foster Wheeler - Indorama, Map Ta Phut Thailand

10 CTA Crystallizer, Foster Wheeler - Indorama, Map Ta Phut Thailand

11 Dissolver Reactor (230 ton), 1.25 Cr alloy w/ 347 SS W.O., AkerKvaerner - Petroquimica Suape, Brazil

PE / HDPE / LDPE / PP

Polyethylene (PE) is a thermoplastic polymer, created through polymerization of ethene and is classified into several categories based on its density and branching.
VRV is approved by the main licensors of Polyethylene (PE) and Polypropylene (PP) production processes: Tecnimont, ExxonMobil and LyondellBasell.
VRV features the complete range of main reactors and heat exchangers for the PE / HDPE / LDPE / PP process, including high pressure components up to 365 bar. These are the following:

- **Loop Reactor**
- **Gas Phase Reactor**
- **High Pressure Recycle Gas Cooler**
- **Soft Product Cooler**
- **Soft Product Separator**
- **High Pressure Separator**
- **High Pressure Wax Separator**
- **Compressor Suction Separator**

12 Was Separator, 15 NiCuMoNb5,
Technip - Arya Sasol Polymer Co., Bandar Assaluyeh Iran

13 Soft Product Separator, 15 NiCuMoNb5,
Tecnimont - Tasnee Petrochemicals, Al Jubail Saudi Arabia


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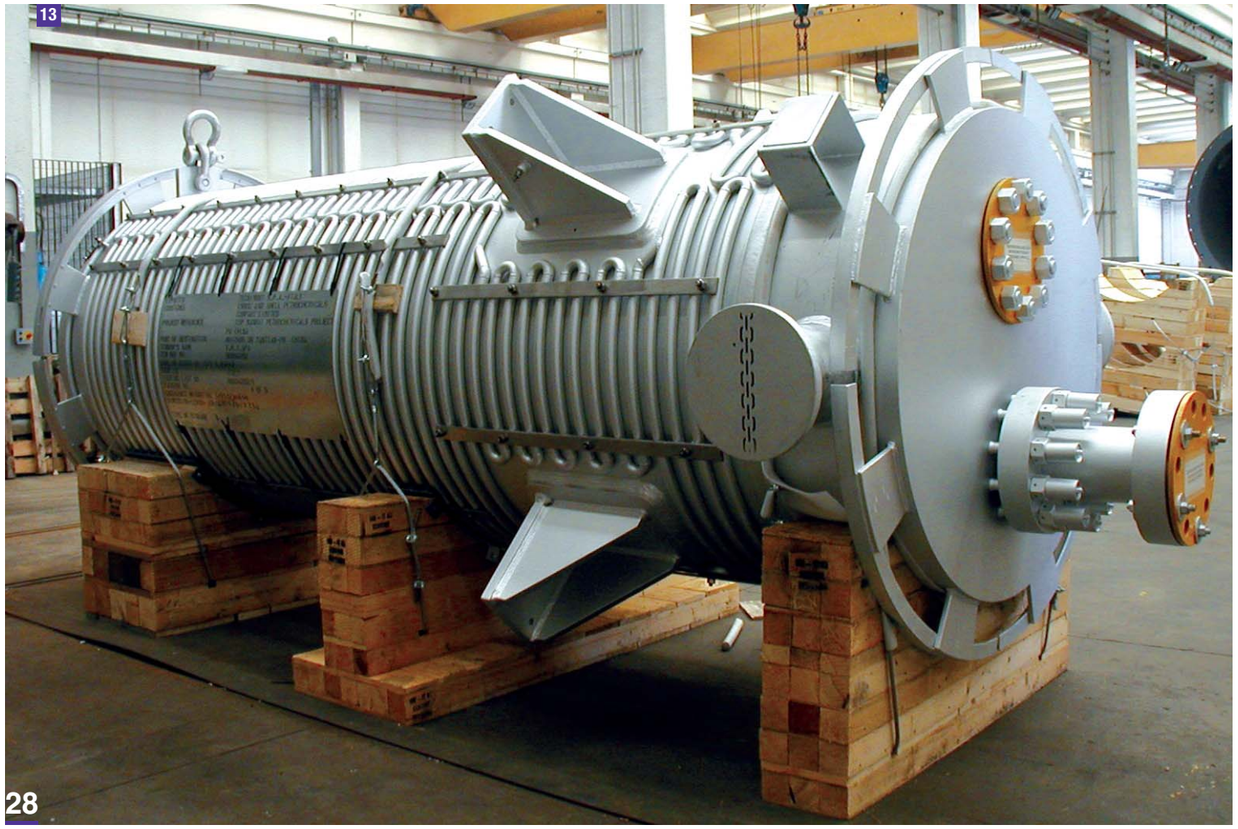
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14 High Pressure Separator, SA 350 Gr. LF2,
Technip - Petkim, Aliaga Turkey

15 HP Recycle Gas Cooler, 15 NiCuMoNb5,
Tecnimont - Tasnee Petrochemicals, Al Jubail Saudi Arabia

16 HP Recycle Gas Cooler, 15 NiCuMoNb5,
Tecnimont - Tasnee Petrochemicals, Al Jubail Saudi Arabia


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PVC

Polyvinyl Chloride (PVC) is the third most widely produced plastic, after polyethylene and polypropylene and is produced by polymerization of the Vinyl Chloride Monomer (VCM).
The most widely used production process is suspension polymerization, for which VCM and water are introduced into the Polymerization Reactor and the Polymerization Initiator, along with other chemical additives to initiate the polymerization reaction.
The content of the reaction vessel is continually mixed to maintain the suspension and ensure a uniform particle size of the PVC resin. The reaction is exothermic, and thus requires a cooling mechanism to maintain the reactor contents at the appropriate temperature. As the volumes also contract during the reaction (PVC is denser than VCM), water is continually added to the mixture to maintain the suspension.
Once the reaction has run its course, the resulting PVC slurry is degassed and stripped to remove excess VCM (which is recycled into the next batch) then passed through a centrifuge to remove most of the excess water. The slurry is then dried further in a hot air bed and the resulting powder sieved before storage or pelletization.
VRV has supplied several Polymerization Reactors to various clients over the years.

PET

Polyethylene Terephthalate (PET) is a thermoplastic polymer resin of the polyester family and is used in synthetic fibers (PET usage in excess of 60% and generally referred to as "polyester"); beverage, food and other liquid containers (PET usage in excess of 30%); thermoforming applications; and engineering resins often in combination with glass fiber.
Its monomer can be synthesized by the esterification reaction between terephthalic acid and ethylene glycol with water as a byproduct, or by transesterification reaction between ethylene glycol and dimethyl terephthalate with methanol as a byproduct. Polymerization is through a polycondensation reaction of the monomers (done immediately after esterification / transesterification) with ethylene glycol as the byproduct (the ethylene glycol is directly recycled in production).
VRV provides several reactor components for the PET production plant, as per the following:

- **Finisher** (horizontal reactor)
- **UFPP** (vertical reactor)
- **Vapor Separator**
- **Exchanger**
- **Esterification Reactor**


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17 Polymerization Reactor,
Sanmprogetti - Dunastir, Szazhalombatta Hungary

18 Polymerization Reactor,
Oltchim SA, Rimnicu Vilcea Romania


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19 Finisher w/ Agitator, SA 516 Gr. 70 w/ SA 230-304 cladding,
Reliance Industries, Hazira India

20 Finisher w/ Agitator, SA 516 Gr. 70 w/ SA 230-304 cladding,
Reliance Industries, Hazira India

21 UFPP, SA 516 Gr. 70 w/ SA 230-304 cladding,
Reliance Industries, Hazira India


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Petrochemical

Melamine

Melamine (66% nitrogen by mass) is used to produce melamine / formaldehyde resins that fit a large variety of applications: flooring, laminates, thermosetting plastic. Other applications include paints, glues, flame retardants and slow-release fertilizers. However, melamine is much more expensive to produce than other common nitrogen fertilizers, such as urea. Melamine is produced from urea by two methods: high-pressure non catalytic liquid-phase production or low-pressure catalyzed gas-phase production.

With the high-pressure method, molten urea is fed at 7-15 MPa to the reactor where it undergoes an endothermic reaction at temperatures of 370-450 Celsius degrees, with heat provided by external sources. Melamine leaves the reactor in liquid phase and after depressurization is quenched with water to separate from off-gas (NH_3 and CO_2). The slurry is further concentrated and crystallized to yield melamine.

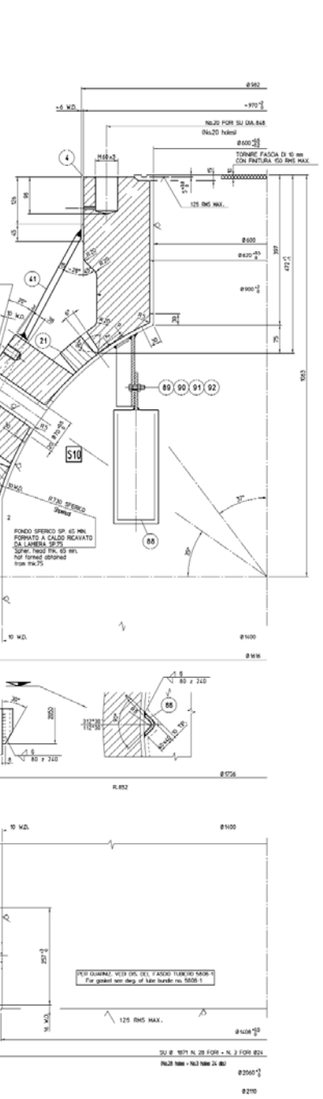
With the low-pressure method, the reaction is carried out using a catalyst in a fluidized bed reactor, under pressure of 0.5-1 MPa and temperatures of 390-440 Celsius degrees. The fluidizing gas is either ammonia or ammonia-carbon dioxide. Melamine and fluidizing gas leave the reactor in gaseous phase and are quenched by water or cold reaction gas.

VRV is approved by the major melamine process licensors such as Eurotecnica and Agrolinz. VRV provides several components for the melamine production plant and these are:

- **Reactor**
- **HP Steam Generator**
- **HP Scrubber**
- **Stripper**
- **Quencher**

22 Reactor, 2.25 Cr alloy w/ C276 W.O., Agrolinz Melamin, Castellanza Italy

23 Typical drawing of Melamine Reactor w/ C-276 W.O.



24 /25 /26 Reactor w/ Tube Bundle, 2.25 Cr alloy w/ C276 W.O., Agrolinz Melamin, Linz Austria

Fertilizer

VRV has supplied critical equipments for over 50 years to fertilizer projects for the production of Ammonia, Urea, Methanol all around the world.

Major equipment supplied include converters / reactors, boiler feed water heaters, secondary reformers, synloop heat exchangers, MP/LP decomposers, converter cartridges, carbamate condensers and a range of high-pressure heat exchangers and pressure vessels for fertilizer plants.

Special techniques are followed during the fabrication of sophisticated and tailor-made components, for which VRV is highly qualified: Internal Bore Welding (IBW), special material alloy overlay (C59) and double tube-sheets applications.

In addition, VRV offers a range of engineering services, including Thermal Design (HTRI / HTFS), Mechanical Design Finite Element analysis (ANSYS) and detailed Flow Induced Vibrations analysis (FIV) and Advanced Pressure Vessels analysis (APV).

The design and fabrication of the above components are carried out in accordance with the specifications of the most recognized process licensors: Haldor Topsoe, Linde, Uhde, Casale, Kellogg and Snamprogetti.

Ammonia

The synthesis of ammonia uses a form of magnetite, iron oxide, as the catalyst of a reaction held at 15-25 Mpa and between 300-550 Celsius degrees, passing the gaseous nitrogen and hydrogen over 4 beds of catalyst, with cooling after each pass with a conversion rate up to 15% and a recycling mechanism to achieve up to 98% conversion.
The major source of hydrogen is methane from natural gas, however, sometimes (i.e. China, Australia) coal may be used as a source through a process called coal gasification. Initially, methane is cleaned primarily to remove sulphur impurities that would poison the catalyst, then clean methane reacts with steam in the primary reforming stage and with air in the secondary reforming stage, over a catalyst of nickel oxide.
The water-gas shift reaction yields more hydrogen from carbon monoxide and steam, then the gas mixture goes through a methanator, which converts the remaining carbon monoxide into methane for recycling purposes.
The production of ammonia is based on proprietary technology by a number of licensors (Haldor Topsoe, Linde, Uhde, KBR, Ammonia Casale) for which VRV is an approved vendor.
With regard to the equipment required in an ammonia production plant, VRV can supply the following:

- **Ammonia Synthesis Converter**
- **Boiler Feed Water Heater**
- **Synloop Heat Exchanger**
- **Secondary Steam Reformer**
- **Exchange Reformer** (Haldor Topsoe license)
- **Ammonia Synthesis Converter Cartridge (Basket)**

1 Ammonia Converter, 20MnMoNi 4 5,
Uhde - Kuibyshev Azot, Kuibishevsk Russia

2 HP Steam Superheater, 2.25 Cr alloy,
Jacobs - Yara, Ferrara Italy

3 BFW Preheater, 2.25 Cr alloy,
Jacobs - Yara, Ferrara Italy

4 Secondary Reformer, SA 204 Gr. B,
Technip - Wesfarmers CBSP, Australia

For the ammonia synthesis, VRV supplies proprietary technology items like the Ammonia Converter Internals (i.e. Baskets or Cartridges) to all main licensors of the ammonia process. These items are very sophisticated in the design and construction materials and require major expertise in the fabrication procedures.
Since the late 80's VRV has supplied in excess of 60 Ammonia Converter Baskets to various licenses and designs with radial flow and single-bed, two-bed or the latest developed three-bed catalyst design.

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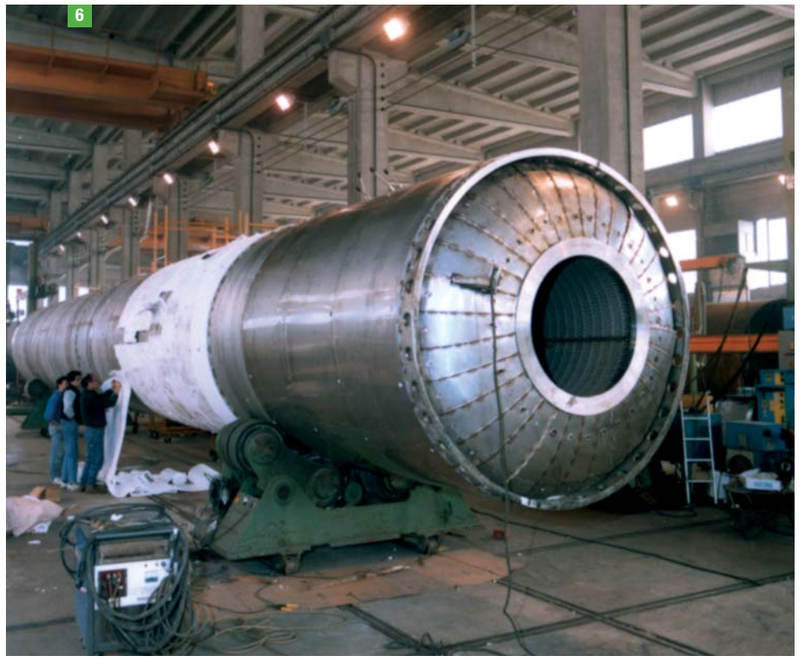
5 Ammonia Converter Basket (160 ton), 321 SS,
Topsoe - Eagrum, Canada



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6 Ammonia Converter Basket, 321 SS,
Ammonia Casale - Pritchard Farmland Ind., Kansas USA

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7 Ammonia Converter Basket, 304 SS,
Uhde - Kuibyshev Azot, Kuibishevsk Russia

8 Ammonia Converter Basket, 321 SS,
Ammonia Casale - Tianjin Chemical Ind., Tianjin China

9 Ammonia Converter Basket, 321 SS,
Topsoe - Ca Mau Fertlizer, Ca Mau Vietnam

Urea

Urea is an organic compound $(NH_2)_2CO$, a carbonyl group attached to two organic amine residues.
It is solid, colourless, odourless, highly soluble in water and widely (90% of its world production) used in fertilizer as a convenient source of nitrogen, as it has the highest nitrogen content of all nitrogenous fertilizers in use (47%).
Urea is produced from synthetic ammonia and carbon dioxide, which is produced in large quantity during the production of ammonia from coal or from methane. The process consists of two main reactions, the first one is exothermic between liquid ammonia and dry ice to form ammonium carbamate, the second is an endothermic decomposition of ammonium carbamate into urea and water.
The main urea process licensors are Snamprogetti, Urea Casale, Kellogg and Stamicarbon.
VRV provides the following key components for the urea production plant:

- Urea Reactors
- Carbamate Condensers
- Medium-Low Pressure Decomposers

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10 LP Decomposer, 316L SS,
Mitsubishi - El Omania, Algeria

11 Carbamate Condenser, 25 22 2 CrNiMo,
Snamprogetti - Guanxi China

12


13

12 MP Decomposer, 25 22 2 CrNiMo,
Mitsubishi - El Omania, Algeria

13 Typical arrangement of Ferrules on
Decomposer Exchanger

14 Vacuum Preconcentrator, 316L SS,
Mitsubishi - El Omania, Algeria


14

Methanol

Methanol is a chemical with formula CH_3OH and is an alcohol, light, volatile, colourless and flammable, commonly used as a laboratory solvent. It is widely utilized in making other chemicals, about 40% of methanol is converted to formaldehyde and from there into a variety of products like plastics, plywood, paints and explosives.
In the methanol production process, the synthesis gas is most commonly produced from the methane component in natural gas rather than from coal.
Methane reacts with steam (steam-methane reforming) on a nickel catalyst to produce syngas at 4 MPa and 850 Celsius degrees producing carbon monoxide and hydrogen.
In a secondary reaction at 5-10 MPa and 250 Celsius degrees carbon monoxide and hydrogen react on a different catalyst (mixture of cooper, zinc oxide and alumina) to produce methanol.
The main licensors for the methanol process are Topsoe and Methanol Casale, for which VRV is an approved vendor.
With regard to the equipment required in a methanol production plant, VRV provides the following:

- Methanol Reactor
- Boiler Feed Water
- Heaters

15 BFW Heater, 1.25 Cr alloy,
Ammonia Casale - SABIC, Al Jubail Saudi Arabia

16 Fountain-type Bundle for BFW

17 Methanol Plant

Process

Polysilicon

Polysilicon and Flash Technologies are two areas of application for which VRV supplies proprietary equipment and process technologies as complete packages for its customers.

Polysilicon is produced industrially to obtain the mono-crystal silicon, which is used in the photovoltaic industry to manufacture solar panels (solar grade) and microelectronics industry for the integrated circuits and CPUs (electronic grade).
With dedicated resources and the know-how achieved by a cooperation of 30-year experience of technology providers, VRV can offer the most comprehensive and experienced, one-step technology to comply with the highest demanding standards of the polysilicon industry.

Flash

The “Flash” system is an advanced technology for reaction, drying and granulation, based on the principle of mechanical centrifugation to create, inside the equipment, the product conditions in a dynamic and turbulent thin layer, in atmosphere of air, gas, vapours or under vacuum.
The main fields of application for “Flash” are:

- Chemical industry: dyestuffs and pigments, organic and inorganic salts, organic intermediates, civil and industrial waste and sludge’s, metallic stearates / oleates / palmitates production, salification reactions
- Pharmaceutical industry: antibiotics and intermediates vegetal / animal extracts
- Detergents industry: fatty acids sulphates, alchilic / arilic sulphonates, saponification starting from free fatty acids
- Food industry: starch and derivates
- Polymer industry: poly-condensation reactions

VRV patents:
- Italian Patent No. 01248826
- European Patent No. 0459328
- US Patent No. 5,197,205

Polysilicon

Polysilicon can be produced by Chemical Vapour Deposition (CVD), mixing trichlorosilane ($SiHCl_3$) and hydrogen (H_2) in a reactor at extremely high temperature (up to 1150 Celsius degrees) through the deposition of silicium on a filament run by electric current. VRV has been the leading manufacturer of CVD Reactors and STC Converters for the last 25 years with the supply of more than 350 reactors and has the strongest track records for this type of equipment supplied in the past 5 years to the polysilicon industry. In consideration of the growing demand of the photovoltaic industry, since 2004, VRV developed the first ever 36-rod design for the Polysilicon Reactor. Over the years, due to the market demand for more efficiency and reduced power consumption in the polysilicon production, VRV has designed and supplied the 48-rod and 54-rod design for several customers.
In addition to the equipment, VRV can deliver Process Design Packages (PDP), which can be converted into Basic and Detail Design by any qualified EPC contractor. VRV provides the following products and services:

- **CVD Reactor and STC Converter**
- **TCS synthesis**
- **TCS purification and chlorosilane distillation**
- **Hydrogen purification**
- **Polysilicon Plant Integration & Overall plant mass balance**
- **Filament Facility**
- **Product Handling**
- **Energy consumption reduction (heat recovery)**
- **Performance Improvement on existing CVD Reactors / STC Converters**
- **Close cooperation with qualified EPC companies during engineering and construction.**
- **Training**
- **Commissioning, start-up and operation support**
- **Assistance in technology consulting and auditing, feasibility studies, engineering, conceptual and design.**

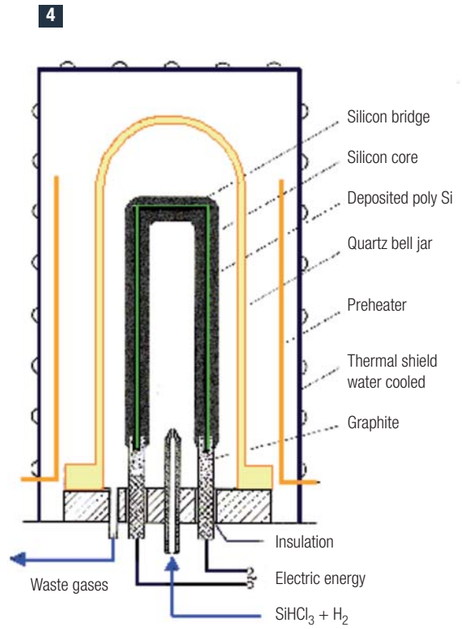
1 CVD Reactor, 36 rods,
SA 516 70 Cladded SA 230-304, SETEK, Japan

2 CVD Reactor - Internal Mirror Polishing

3 CVD Reactor, 48 rods,
SA 516 70 Cladded SA 230-304,
GT Solar - SHUNDA, China

4 CVD Reactor Schematic

5 CVD Reactor - External Insulation



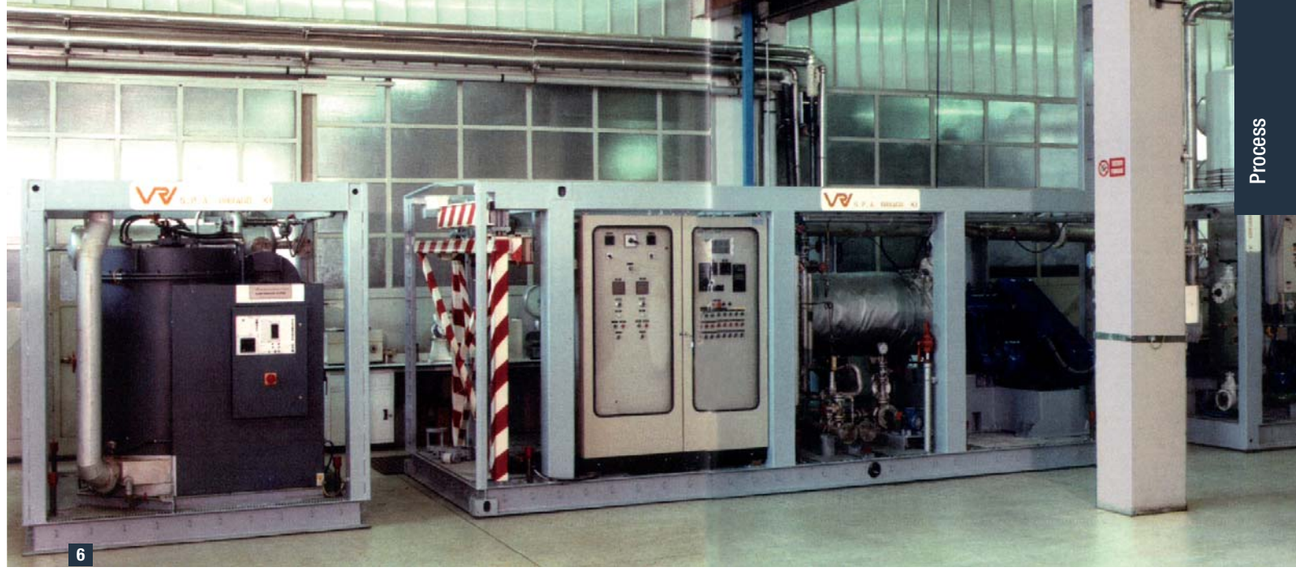
Flash

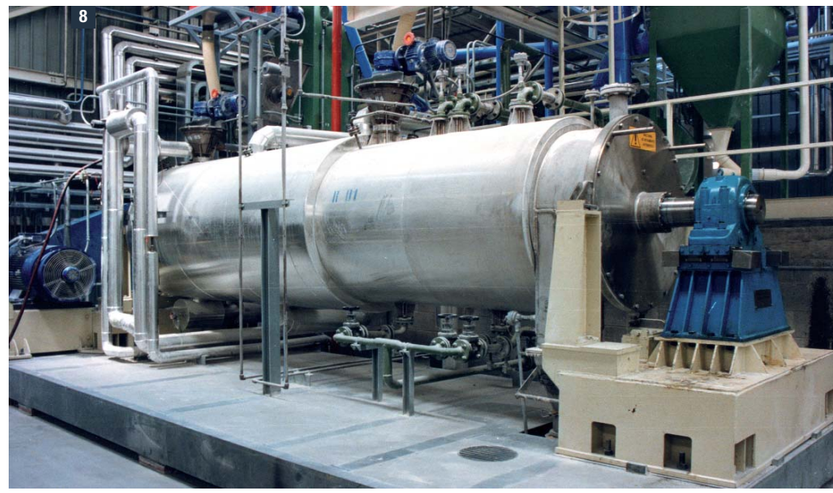
The Flash equipment consists of two main components: a rotor with blades functioning as centrifugal and mixing elements, a stator with heating or cooling jacket.
Operating with a dynamic and turbulent thin layer of product and minimum contact times of the product with the walls, it can reach high temperature differences without deterioration of the product and elevated coefficient of thermal exchange due to conduction through the stator hot wall and convection through preheated flow of air or gas.

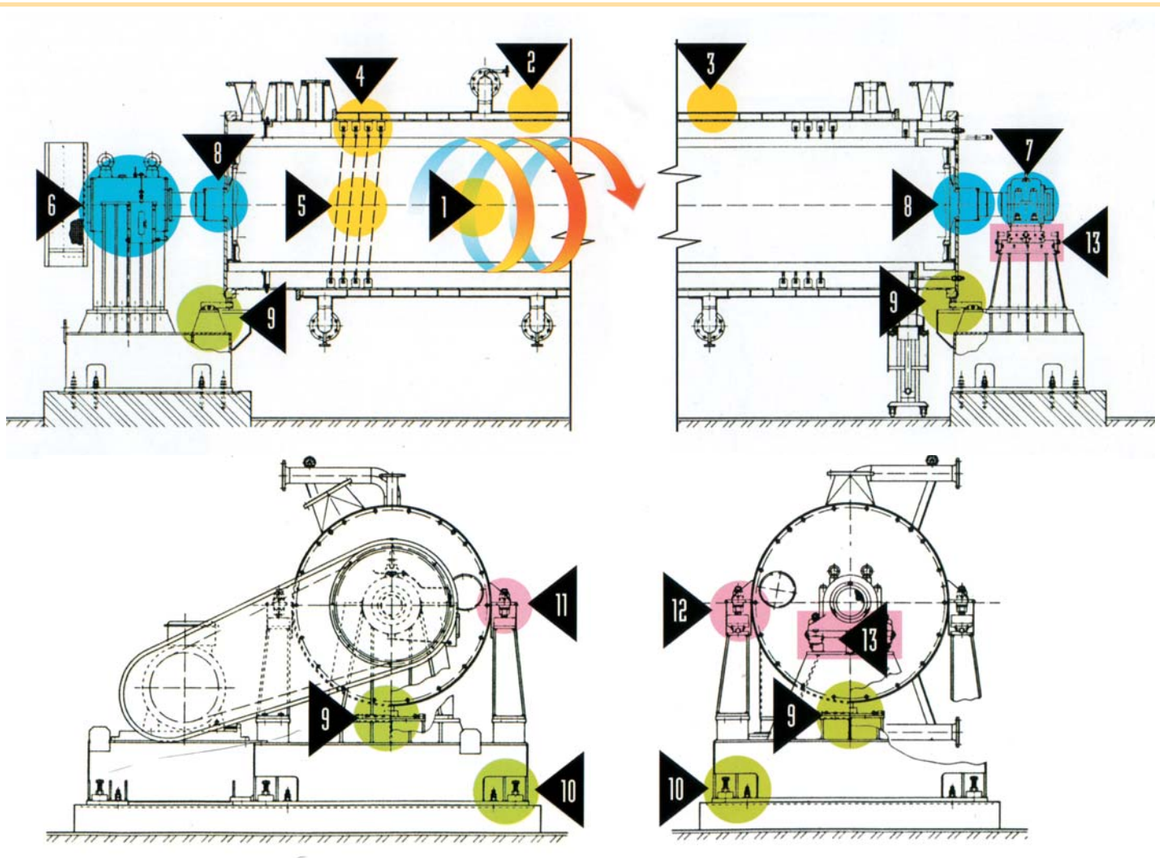
VRV designs and manufactures the below equipment types:
- **Flash Drier**, dynamic thin layer centrifugal drier-granulator
- **Eco Flash**, ecological version for municipal and industrial treatment of sludge
- **Flash Reactor**, combined technology for mixing, reaction, drying and granulation

The process main characteristics and parameters are:
- High reaction / drying efficiency
- Short process time: 1÷10 min
- Evaporation capacity: 50÷3000 Kg/h (water)
- Residual humidity down to 0.1%
- Heating temperature: up to 300 °C
- Granulometric range: 5÷3000 micron

The Flash configuration can be:
- Atmospheric (closed or open cycle)
- Under vacuum
- Under controlled/inert atmosphere (N_2-CO_2-SO_2)

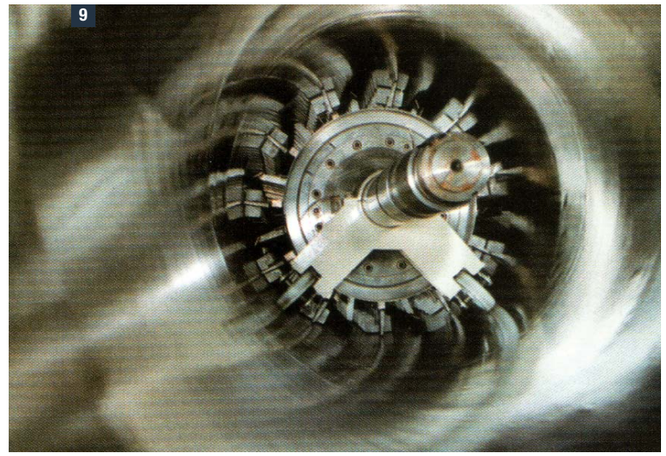






BASIC MODEL
Main construction features

1. Rotor
2. Stator
3. Stator
4. Centrifugation and mixing elements
5. Blades helical arrangement and product forward movement
6. Rotor support (driving side)
7. Rotor support (driven side)
8. Rotating shaft tightness device
9. Centring and axial sliding device
10. Device for bedplates coplanarity adjustment
11. Devices for compensation of stator radial expansion
12. Devices for compensation of stator radial and axial expansion
13. Devices for compensation of stator axial expansion



6 Demonstrative Mobile Skid-mounted Unit

7 Mobile Unit Operating at Customer's Plant

8 Flash Reactor Driving Side View

9 Flash Rotor

Cryogenic

The Cryogenic Division activity ranges from industrial, medical and special applications to static and mobile, standard and engineered tanks, with perlite and super-insulated technology. The division is applying innovative procedures for the manufacture of equipment for the storage, transport and distribution of liquefied gases (LIN-LOX-LAR-LHe-LCO_2-LN_2O-LNG-LH_2). The manufacturing facilities in Italy, France and India provide a complete range of cryogenic solutions from the beginning to the end of the supply chain.

Cryogenic

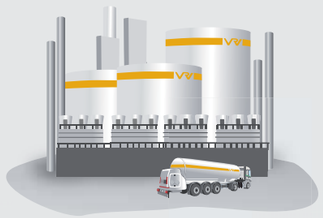
VRV has been designing and manufacturing high-quality cryogenic equipment for over 50 years:

- **Cryogenic Bulk Storage Tanks** (from 2,000 to 60,000 litres - 4 to 37 bar)
- **Custom-made Storage Tanks** (up to 5,000,000 litres)
- **Microbulk Cryogenic Tanks** (120 to 2,000 litres - 4 to 37 bar)
- **Cryogenic Transport Equipment** (delivery units, semi-trailers and ISO containers)
- **Ambient Air Vaporizers**
- **Nitrogen Tanks for the Service Companies to Oil & Gas Industry**
- **Cryo Solutions for Artificial Insemination**
- **Turnkey Systems for Cryobiological Storage**
- **Liquid Helium Dewars and Tanks**
- **Homecare Medical Systems for Liquid Oxygen**
- **Vacuum Insulated Piping**
- **Turnkey Cryogenic Installations for the LNG market**

1 Cryogenic applications

1

Engineered cryogenic storage tanks



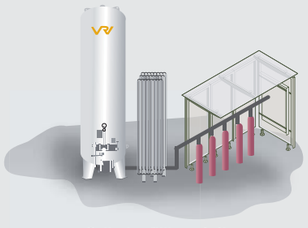
Air gases liquefaction plant

Vacuum insulated lines

Delivery units

Semi-trailers
Yellow - Steel - Flexi

ISO containers
Ulysses



Cylinder filling station

Industrial Application

Vaporizers
Static cryogenic storage tanks / *Eagle*

Liquid nitrogen dewars

Liquid gas containers
Cryo-Cyls

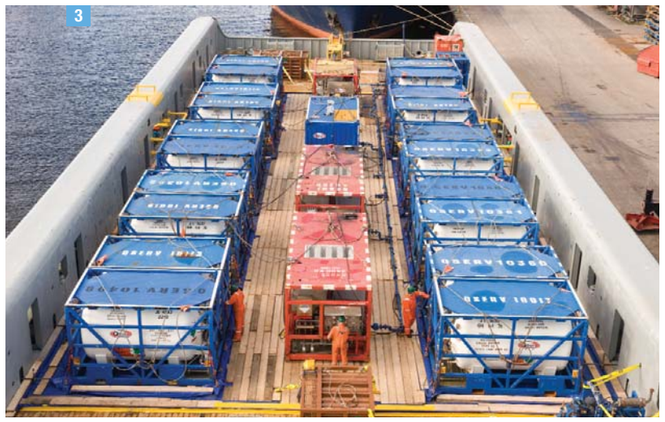
2 Cryogenic Semi-Trailer

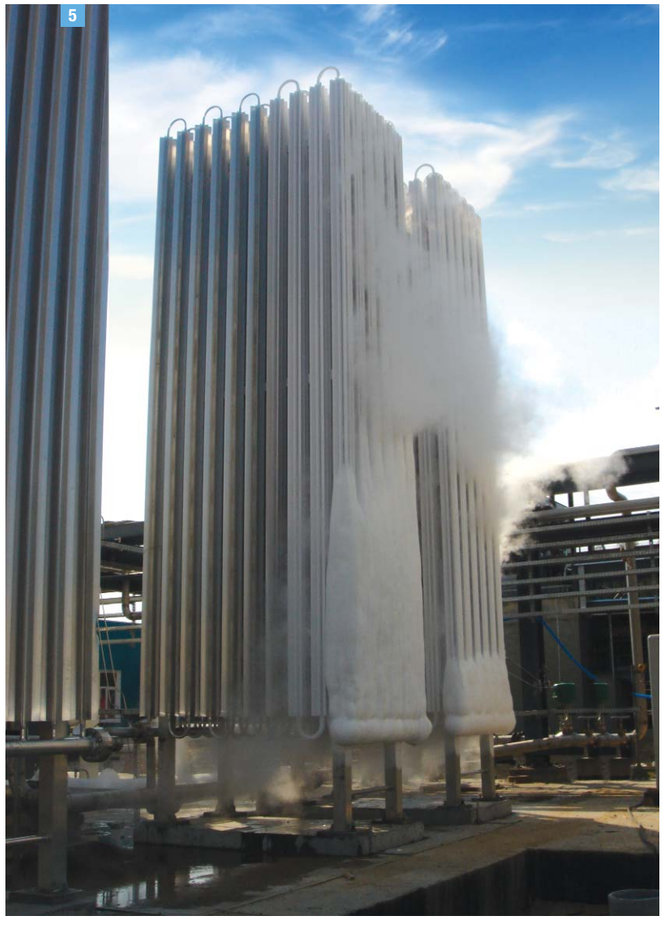
3 Offshore ISO containers

4 Vertical Engineered Cryogenic Tanks

5 Vaporizers

6 Vacuum insulated lines





Research & Development

VRV always offers state-of-the-art solutions in order to fully satisfy customers' expectations.
Thus, we regularly upgrade our facilities / capacities with new and powerful equipment and we devote considerable efforts into continuous R&D.
We constantly cooperate with our customers in new design approaches, new fabrication technologies, new material utilization and special projects.
VRV, together with research institutes and universities, has established a centre for developing products with advanced technologies.
The development of the company welding process is the responsibility of training centres and welding institutes.
The technical competence of our Engineers and Specialists is a guarantee for outstanding results and achievements for the most ambitious and challenging projects.

VRV NUCLEAR - VRV has recently taken the first steps for certification to operate in the nuclear sector, in the spirit of our "Continuous Improvement" policy. We have started the process to get the accreditation "N", "NPT" and "NS" Stamp from the American Society of Mechanical Engineers (ASME).