Environmental Solutions
Making the World a Better Place for the Next Generation
3V Green Eagle was established in 2000 by the multinational 3V Group, a corporation that has almost sixty years of experience in sophisticated chemical production, advanced chemical engineering and the manufacturing of process systems and equipment. These foundations have given 3V Green Eagle an insightful understanding of the environmental issues faced in the chemical engineering industry. For this reason, we are a unique company in the environmental sector with the ability to offer single-sourced and full service solutions.

In order to optimize the development of our technologies, our researchers, chemical production managers, process engineers, mechanical engineers and constructors are continuously in collaboration. In this way, we have been able to create a solid and multidisciplinary technical culture which offers a wide range of environmental solutions to the manufacturing, municipal, oil and gas and remediation industries.

Additionally, we operate the largest industrial wastewater and sludge treatment center in Italy.
“A CLEAN ENVIRONMENT IS A HUMAN RIGHT LIKE ANY OTHER. IT IS THEREFORE PART OF OUR RESPONSIBILITY TOWARD OTHERS TO ENSURE THAT THE WORLD WE PASS ON IS AS HEALTHY, IF NOT HEALTHIER, THAN WE FOUND IT.”

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3V GROUP
Overview

A DYNAMIC GROUP DIVIDED INTO 3 DIVERSE CONSTITUENT COMPANIES

3V TECH
MANUFACTURING PROCESS SYSTEMS AND EQUIPMENT
A leading provider of advanced process systems and equipment for several industries. The company is specialized in separation, drying, reaction and glass-lining.

3V CHEMICAL
SPECIALTY CHEMICAL PRODUCTION
Manufactures fine chemicals that are used in paper, detergents, cosmetics, water treatment, plastics, surface treatments, refinery and oil and gas applications. The company’s products include: rheology modifiers, UV stabilizers, antioxidants, radical scavengers, suspending agents, preservatives and optical brighteners.

3V GREEN EAGLE
PROVIDER OF ENVIRONMENTAL SOLUTIONS
Offers environmental solutions for the manufacturing, municipal, remediation and oil and gas industries. Specialized in waste treatment.
3V Group was founded in 1958 in Italy and is active in the following fields:

- Fine chemicals production
- Advanced chemical engineering
- Manufacturing process systems & equipment
- Environmental Solutions & Technologies
- Waste treatment operation and management

**Number of Employees:** 650
3V Group was founded in 1958 as a family-owned entrepreneurial company for the industrial production of specialty chemicals in Italy. We have since experienced significant growth at both a national and an international level as we established a joint venture with ENI (Italian National Oil Company) for producing innovative chemical compounds. Additionally, we expanded our geographical presence to the United States of America as our largest manufacturing facility is operating in South Carolina.

3V Group currently employs more than 650 people who deliver an overall annual turnover of approximately 185 million euros.

Since being founded, 3V Group was investing in the advancement of in-house research and development facilities, process engineering know-how and our internal interdisciplinary skills. These continued investments were contributing to the constant diversification of the production activities performed by the 3V Group. As well as producing specialty chemicals, we began to manufacture process systems and equipment which were available for both internal and commercial uses, particularly by chemical, petrochemical and pharmaceutical industries. This led to the foundation of 3V Tech within the 3V Group in an attempt to further grow and develop the manufacturing of industrial process systems and equipment.

In addition to the production of process systems and equipment, the 3V Group has also entered the environmental business. Due to the increased environmental awareness in Italy which led to new regulation that enforced strict control on industrial wastewater discharge, the 3V Group developed its own industrial wastewater treatment center in Grassobbio. This center allows us to treat wastewater recalcitrant compounds produced by our specialty chemical facility. In addition, we have focused on developing innovative and advanced technologies at the center in order to treat the most difficult liquid waste streams. For this reason, we conducted pilot tests for the development of the wet oxidation technology. This occurred for more than 10 years until the technology was scaled up to an operational and an industrial scale.

As a result of 3V Tech’s engineering and manufacturing capabilities, the 3V Group has been able to constantly develop the technology and the treatment center. In 2001, the center also began treating liquid streams from a wide variety of third parties under the name of a new company called 3V Green Eagle. Both 3V Green Eagle and 3V Tech are two independent companies at present who share the same shareholders as the 3V Group.

3V Green Eagle currently operates a treatment center which serves more than 300 clients and treats in excess of 300 different types of hazardous liquid wastes. This has allowed the center to be the largest in Italy for the treatment of industrial wastewater and sludge as it receives more than 12,000 trucks of hazardous liquid waste per year from all around Italy.
3V Chemicals - Procution plant
South Carolina, USA

3V Chemicals - Procution plant
Grassobbio (BG), Italy

3V Tech - Manufacturing Facility
Dalmine (BG), Italy

3V Tech - Glass Lining Facility
Noventa Di Piave (VE), Italy
3V Green Eagle’s wet oxidation technology, named “TOP® Technology” (Temperature, Oxygen, Pressure), achieves the advanced oxidation of hazardous liquid streams at 300°C, 150 bar, with the injection of pure oxygen gas at an overall flow rate of approximately 20 mc/h. The entire process has been manufactured by 3V Tech, which was also later contracted by 3V Green Eagle in order to provide additional units to further expand and maintain the treatment center.

In 2006, 3V Green Eagle’s treatment center was audited by EU-IPPC auditors and its wastewater treatment process, including the wet oxidation for wastewater and sludge, was classified as the “Best Available Technique” (http://eippcb.jrc.ec.europa.eu/reference/ofc.html) as a “State of the Art” advanced process for treating multi-streams of hazardous liquid waste from a wide variety of industrial processes (such as from adhesives, antibiotics and bactericidal, composting, constructions, cosmetics, detergents, dyes, fine chemicals, food, health sector (hospitals), leather tanning, metals, oil, oil mills, oil and gas, paints, paper, pesticides, petrochemicals, pharmaceuticals, photographic industry, plastics, refineries, resins, textile and wood).

It is worthwhile mentioning that the TOP® - Wet Oxidation Unit installed at 3V Green Eagle’s facility at Grassobbio (BG), Italy normally treats complex streams with high COD (up to 300,000-400,000 mg/L COD) and high salinity. Therefore, our engineers and process managers have gained extensive experience in designing, manufacturing and operating the wet oxidation process in stringent and challenging conditions. As a consequence, we are strongly convinced that 3V Tech has extensive experience and is uniquely positioned to address technological challenges posed by high COD - recalcitrant compounds in wastewaters. Our extensive knowledge of liquid waste treatment coupled with our expertise in engineering and construction has made us confident in offering our technical skills to the market in recent years.

Following the latest expansion of our treatment center in 2010 (contracted to 3V Tech as documented in the following Reference List) and also encouraged by the international recognition of our technology obtained every year since 2006 (EU-IPPC), the 3V Group Board of Directors decided to launch business development activities in 2010 in order to promote our TOP® and Dual TOP® Wet Oxidation technologies at both a national and international level. The business development activities are managed by 3V Green Eagle due to its specific expertise in the environmental sector. Concurrently, the manufacturing and contracting operations are controlled by 3V Tech as they are the process system and manufacturing partner of the 3V Group.

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The business development activities have allowed 3V Green Eagle and 3V Tech to provide a skid mounted wet oxidation unit for a major oil and gas client in the Middle East (Confidential Client). The Wet Oxidation Unit will treat “spent caustic” wastewater for a major refinery in the area. In addition, 3V Green Eagle is currently negotiating other opportunities in:

- China (for 4 private Clients)
- Middle East (to provide a centralized hazardous wastewater treatment center)
- Turkey (for the municipality of its largest cities)
- South America (for the municipality of an important city in Paraguay)
- Italy (for 2 large municipalities and for major oil & gas company)
- United States (for the municipality of one of the largest capitals in the United States)
- Finland (for an international corporation active in the pharmaceutical sector)

3V Green Eagle is currently active in a series of business development activities at international events (such as ACHEMA 2015, WETEX Dubai 2014, IE-Expo Shanghai 2014, ECSM Izmir Turkey 2014, IFAT Munchen 2016). Additionally, 3V Green Eagle is active in prestigious scientific working groups such as Project Routes which was founded by the EU-Commission. According to the research of Project Routes which started in 2011 and concluded in the spring of 2014, the Dual TOP® - 3V Green Eagle Wet Oxidation technology is considered as one of the most viable technological solutions for treating municipal sludge.

We have received deep and extensive international recognition thus far, including a visit by China’s predominant state television broadcaster CCTV (CCTV 10 - Scientific Channel) who visited 3V Green Eagle’s treatment center in July 2014. The full 30 minute documentary aired in China on November 3rd 2014.

In conclusion, we believe that our specialized activities and high-level of expertise has allowed the 3V Group to develop an ideal skill level and knowledge on treating high COD/recalcitrant wastewater streams.
### MILESTONES

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958</td>
<td>First chemical production activities</td>
</tr>
<tr>
<td>1960/70</td>
<td>Industrial development of chemical production and international operations</td>
</tr>
<tr>
<td>1976</td>
<td>3V Group starts designing and constructing equipment and process system for manufacturing industry</td>
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<tr>
<td>1978</td>
<td>3V Group develops a chemical production site in the United States (3V Incorporated)</td>
</tr>
<tr>
<td>1987</td>
<td>Joint Venture with ENI for developing innovative chemical products (CPM Company in Porto Marghera, Venice)</td>
</tr>
<tr>
<td>1990</td>
<td>3V develops and internal treatment center for wastewater and contaminated sludge</td>
</tr>
<tr>
<td>2000</td>
<td>3V Green Eagle is formed in order to further develop and grow wastewater treatment and environmental services</td>
</tr>
<tr>
<td>2003</td>
<td>3V Group enters thermal treatment equipment market (3V MABO)</td>
</tr>
<tr>
<td>2006</td>
<td>TOP® &amp; DUAL TOP® Wet Oxidation technologies for industrial Wastewater &amp; Sludge treatment are classified as “Best Available Techniques” by the European IPPC Commission</td>
</tr>
<tr>
<td>2008</td>
<td>3V Group enters Glass Lining market (3V Glasscoat)</td>
</tr>
<tr>
<td>2014</td>
<td>3V Group acquires CONSITO, a well-known company specialized in chemical engineering technologies, carrying over 45 years of experience</td>
</tr>
<tr>
<td>2014</td>
<td>3V Group and TREVI incorporate the new Company “6V”, which aims to develop and promote environmental technologies for remediating Contaminated Sites</td>
</tr>
<tr>
<td>2014</td>
<td>3V Green Eagle and 3V Tech are awarded by an international Oil&amp;Gas EPC Contractor with no. 2 important contracts for providing a TOP® - Wet Oxidation Unit for “Spent Caustic” wastewater treatment for two relevant Refinery in the Middle East (Oman, Saudia Arabia)</td>
</tr>
</tbody>
</table>
**3V Green Eagle**

**WHO WE ARE**

3V Green Eagle was established in 2000 by the multinational 3V Group, a corporation that has almost sixty years of experience in sophisticated chemical production, advanced chemical engineering and the manufacturing of process systems and equipment. These foundations have given 3V Green Eagle an insightful understanding of the environmental issues faced in the chemical engineering industry. For this reason, we are a unique company in the environmental sector with the ability to offer single-sourced and full service solutions.

In order to optimize the development of our technologies, our researchers, chemical production managers, process engineers, mechanical engineers and constructors are continuously in collaboration. In this way, we have been able to create a solid and multidisciplinary technical culture which offers a wide range of environmental solutions to the manufacturing, municipal, oil and gas and remediation industries.

Additionally, we operate the largest industrial wastewater and sludge treatment center in Italy.

Our in-house treatment technologies have been fully integrated in the center which has allowed us to become specialized in designing, building, operating and maintaining environmental plants (DBOM model). Hence, we offer full plant management and technical advisory which include feasibility studies, laboratory analyses, pilot plant testing and process efficiency consultancy. We also supply chemicals for water and wastewater treatment.
3V Green Eagle provides environmental solutions for the Manufacturing, Municipal, Oil & Gas and Remediation industries and is specialized in waste treatment.

OUR OFFER:

1. OUR TREATMENT SOLUTIONS:
   - Wastewater Treatment
   - Sludge & Sewage Treatment
   - Oil & Solvent Treatment
   - Liquid Off-Spec Product Treatment
   - Soil & Sediment Treatment
   - Tar & Pitch Treatment
   - Drilling Mud Treatment

2. OUR TECHNOLOGY PORTFOLIO
   - TOP® - Wet Air Oxidation for Spent Caustic
   - TOP® - Wet Oxidation for Wastewater
   - TOP® - Wet Oxidation for Sludge
   - DUAL TOP® - Wet Oxidation for Sludge & Wastewater combined
   - Enhanced Biological Treatment
   - Physical-Chemical-treatment
   - Wastewater concentration & drying
   - Zero Liquid Discharge (ZLD)
   - Oil & Solvent recovery
   - Soil & Sediment Washing
   - Pyrolysis
   - Thermal Desorption

3. SUPPLY OF TURN-KEY PLANTS
   - Design, Build, Operate, Maintain (DBOM model)

4. TECHNICAL ADVISORY
   - Process efficiency consultancy
   - Pilot Plant testing
   - Laboratory analysis and consultancy
   - Feasibility studies
THE INDUSTRIES WE SERVE

Manufacturing Industry

3V Green Eagle’s advanced technological capabilities derive from the group’s outstanding chemical production and engineering expertise. The manufacturing industry therefore represents our typical client. For more than 10 years, 3V Green Eagle is operating the largest industrial wastewater and sludge treatment center in Italy, serving almost 200 clients from more than 20 different manufacturing industries, by treating their highly contaminated streams. Thanks to our deep knowledge of a wide variety of contaminated streams and media, we provide Engineering process water solutions in order to optimize waste production, as well as on-site and ex situ environmental remediation services for contaminated soil, groundwater and sediments.

Municipal Industry

Our core expertise in the municipal industry lies in providing centralized wastewater & sludge treatment services. For instance, the process of Municipal Sewage Treatment produces significant quantities of sludge as a result of biologic degradation occurring in standard sewage treatment units. Management of produced sludge is today a topic interest on a global scale, as the installation of Municipal Sewage Treatment Plant is increasing as worldwide urbanization is growing and population accumulates towards large cities and capitals. Large Industrial Wastewater treatment center can be also operated by Municipal entities. 3V Green Eagle is not only a technology provider but can also operate and maintain large municipal water and wastewater treatment centers thanks to the longstanding experience we gained from operating the largest wastewater and sludge treatment center in Italy.
We provide Environmental Solutions for the Oil & Gas Industry, focusing on both Upstream and Downstream applications. Thermal separation technologies provide a solid and technologically sound approach for oil recovery from drilling muds, via thermal desorption. Thermal separation is also widely adopted in order to treat high salinity produced water during regular oil production phase, as well as in recent application on Shale Gas Produced Water treatment (Fracking Waters). Still in the Upstream sector, Wet Oxidation is a recommended treatment process for wastewater produced during oil production from Shale (Shale Oil Production). Downstream applications in the Oil & Gas Industry are related to On Site/Ex Situ treatment of environmental media as contaminated soil and sediment via Soil Washing and wastewater treatment and contaminant destruction by Wet Oxidation (TOP technology).

The US Environmental Protection Agency defined Environmental Remediation as “Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a contaminated site”. Remediation technologies can be classified into Ex-Situ and In-Situ methods. While In-Situ methods treat the contamination without removing the soils, Ex-Situ methods involve removal of affected soils and subsequent treatment, which can occur “On site”, when the treating unit is local at the contaminated site, or “Ex-Situ” when the treatment process is located at a dedicated facility. 3V Green Eagle has developed a specific expertise in treating contaminated media coming from the manufacturing industry via On-site and Ex-Situ technologies. The combination of proven remediation technologies, such as Soil Washing with technologies successfully used in the industrial sector, is ideal for effectively dealing with the problems caused by polluted sites.
OUR TREATMENT SOLUTIONS

- Wastewater Spent Caustic ZLD Treatment
- Tar & Pitch Treatment
- Soil & Sediment Treatment
- Sludge & Sewage Treatment
- Oil & Solvent Treatment
- Drilling Mud Treatment
Wastewater Spent Caustic ZLD Treatment

Our wide range of experiences in this field has allowed us to develop several highly efficient solutions for wastewater treatment.

Our wastewater treatment solutions are specifically tailored for each of our clients as 3V Green Eagle understands that treatment requirements can differ based on the type and concentration of contaminants in wastes.

What we offer:

We are highly trained in treating different types of wastewater using well-researched methods. These include:

1. Wastewater treatment and organic load reduction via the TOP® - Wet Oxidation technology. This treatment is combined with enhanced biological processes and chemical-physical processes in order to treat a wide range of wastewater types.

2. Spent Caustic Stream Treatment via the TOP® - Wet Oxidation technology in order to reduce COD load and micropollutants.

3. Wastewater concentration and drying, as well as Zero Liquid Discharge (ZLD) technologies which allow the treatment of solvent-rich and highly saline wastewater. In some cases, we can offer solvent recovery processes if it is economically viable.

Additional services we offer here:

- Design Build Operate Maintain (DBOM model)
- Plant Management
- Process efficiency consultancy
- Pilot Plant testing
- Laboratory analysis’s & consultancy
- Feasibility studies
3V Green Eagle operates the largest industrial wastewater & sludge treatment center in Italy

We are highly accomplished in handling and treating contaminated liquids due to our long experience in the chemical production and the environmental fields.

The manner in which we have integrated the innovative, state-of-the-art best available techniques, combined with our experience in operating and maintaining the largest multi-stream wastewater treatment center in Italy, makes 3V Green Eagle the ideal partner in addressing industrial wastewater treatment challenges.

Types of wastewater we treat:

**Manufacturing Industry**
- Adhesives
- Antibiotics and bactericidal
- Composting
- Constructions
- Cosmetics
- Detergents
- Dyes
- Fine Chemicals
- Food
- Health Sector (Hospitals)
- Leathet Tanning
- Metals
- Oil
- Oil mills
- Paints
- Paper
- Pesticides
- Pharmaceuticals
- Photographic Industry
- Plastics
- Resins
- Textile
- Wood

**Municipal Industry**
- Liquid Sludge
- Leachates from Disposal
- Drains coming from Septic Tanks
- Water Pumped from Polluted

**Remediation Industry**
- Hydraulic barriers
- Wells
- Soil washing
- Tank decommissioning

**Oil & Gas Industry**
- Production and Extraction wastewater containing glycols and hydrocarbons
- Fracking water
- Production water from shale oil and water resulting from phase separation
- Naphthenic spent caustic
- Cresylic spent caustic
- Sulphidic spent caustic
- Ethylene spent caustic

**Technologies we apply here:**
- TOP® - Wet Oxidation for Wastewater
- TOP® - Wet Air Oxidation for Spent Caustic
- Enhanced Biological Treatment
- Physical-Chemical-treatment
- Wastewater concentration & drying
- Zero Liquid Discharge (ZLD)
- Oil & Solvent recovery
Sludge & Sewage Treatment

Municipal and industrial sewage treatment processes produce significant quantities of sludge as a result of biologic degradation occurring in standard sewage treatment units. The management of this sludge has become a topic of interest on a global scale due to a worldwide increase in urbanization.

At a global level, several sewage sludge disposal methods have been implemented of which the most common ones include:

- Agricultural treatment, as sewage sludge is rich in nutrients including carbon, nitrogen and phosphorus.
- Landfilling, as sewage sludge can contain heavy metals and micropollutants, making it unsuitable for agricultural use.
- Incineration with energy recovery, in order to maximize the use of the high energy content of dried sludge.

**What we offer:**

Our TOP® for Sludge and Dual TOP® - Wet Oxidation technologies are consistently successful in achieving:

- Significant reductions in sludge volume
- The stabilization of sludge and dissolved metals
- The removal of the microbial load
- The partial or full mineralization of the sludge
- A Zero Discharge process
- High safety standards without the use of hazardous gaseous compounds

**Technologies we apply here:**

- TOP® - Wet Oxidation for Sludge
- DUAL TOP® - Wet Oxidation for Sludge & Wastewater combined
- Enhanced Biological Treatment
- Physical-Chemical-treatment
- Wastewater concentration & drying
- Oil & Solvent recovery

**Additional services we offer here:**

- Design Build Operate Maintain (DBOM model)
- Plant Management
- Process efficiency consultancy
- Pilot Plant testing
- Laboratory analysis’s & consultancy
- Feasibility studies
After oxidizing the organic fraction of the sludge using the TOP® - Wet Oxidation process, the solid fraction is recovered from the effluent as a solid, highly oxidized and inorganic residual. This residual can be reused as primary-secondary material, either as it is or in combination with other substances.
Oil & Solvent Treatment & Recovery

3V Green Eagle has gained extensive experience in designing, building and installing process equipment in order to implement the most innovative distillation technologies.

Our innovative distillation technologies allow oils, solvents and chemical products to be separated from waste mixtures in order to be salvaged and utilized for other purposes. Typical waste mixtures include: solvents, waste oils, oil sludge, pitch, acid wastewater from pickling and metals.

Each application is unique and therefore requires simulations, field testing, pilot tests, construction and system testing in the factory before the treatment process is implemented.

What we offer:

- A modular, elastic and flexible solvent recovery system capable of using dozens of solvents that would otherwise be incinerated.
- A distillation system which is able to salvage solvents mixed with thermolabile solids.
- A unique, original, stable and reliable system with a continuous process.
- Systems which recycle automotive waste oils.
- Re-refining technologies.
- Vacuum distillation, without acid treatment and with a minimization of waste. Costly liquid-liquid or super-critical extraction is not needed.
- A flexible and adaptable system for different types of sludge.
- Direct contact with our engineers and high engagement with the development of the treatment process.

Technologies we apply here:

- Wastewater concentration & drying
- Oil & Solvent recovery
- Thermal Desorption

Additional services we offer here:

- Design Build Operate Maintain (DBOM model)
- Pilot Plant testing
- Plant Management
- Laboratory analysis’s & consultancy
- Process efficiency consultancy
- Feasibility studies
• Solvent Recovery Italy

Awarded by the Italian Environmental Ministry as best sustainable environmental technology in 2012
Soil & Sediment Treatment

3V Green Eagle in collaboration with TREVI created the company 6V to optimize the performance of land reclamation and environmental restoration works mainly through on-site techniques, including the management, treatment and recovery of contaminated soils and sediments - within infrastructural works - land reclamation works and confinement of polluted sites.

The environmental sustainability of the local surroundings must always be considered highly in infrastructural projects. The restoration and enhancement of brownfield sites, as well as activities involving the infrastructural improvement of coastal ports, are conducted in areas in which water, air, soil and marine, river or lake sediments have been contaminated throughout history.

From this, it follows that certain technical and environmental issues are created due to the need for huge sediment dredging works within hydraulic infrastructures. Similar issues need to be tackled when it comes to managing massive amounts of soil in case of works in land reclamation or the confinement of contaminated sites. Adopting a multidisciplinary approach is therefore the key to the problem.

What we offer:

6V’s first soil-washing plant can process up to 60 tons of soil per hour, contaminated sediments (special attention is paid to the hydrocarbon contamination) or residues from drill spoils, in order to re-use the recoverable sand and aggregates for other production processes or environmental restoration activities. The plant is certified as a mobile plant for waste treatment, pursuant to Italian regulations.

Technologies we apply here:

DUAL TOP® - Wet Oxidation for Sludge & Wastewater combined
Soil & Sediment Washing
Thermal Desorption

Additional services we offer here:

- Design Build Operate Maintain (DBOM model)
- Plant Management
- Process efficiency consultancy
- Pilot Plant testing
- Laboratory analysis’s & consultancy
- Feasibility studies
**IN SITU**
- CUT OFF WALLS
- PHYSICAL CONTAINMENT
- PERMEABLE REACTIVE BARRIERS
- SOLIDIFICATION & STABILIZATION
- CHEMICAL TREATMENT

**ON SITU**
- SOIL & SEDIMENT WASHING

**EX SITU**
- INDUSTRIAL WASTEWATER AND SLUDGE TREATMENT
- SOIL & SOLVENT RECOVERY
- ZERO LIQUID DISCHARGE
- THERMAL DESORPTION
- PYROLYSIS

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**TREVI**
- Leader in Ground Engineering
- Part of TREVI Group, Active in Civil, Mechanical and Oil & Gas Engineering
- Yearly Turnover € 1.25 B
- 7600 Employees

**3V GREEN EAGLE**
- Leader in Environmental Technologies for Waste Treatment
- Part of 3V Group, Active in Specialty Chemicals and Process Solutions
- Yearly Turnover € 200 M
- 700 Employees
Tar & Pitch Treatment

Tar and pitch are thick, semisolid, residuals composed of complex hydrocarbons which are obtained via the distillation of carbonaceous materials. These residuals are a common solid waste of the chemical and petrochemical industry.

3V Green Eagle has gained experience in treating these types of waste with pyrolysis technology. Pyrolysis allows for the thermal valorization of the intrinsic calorific power of such residuals and is also able to significantly reduce their volume so that only the inorganic fraction of the material is left. Reductions can range between 90 to 95% percent of the original volume. Recovering energy allows pyrolysis to be a self-sustaining process. The excess heat in the process can also be recycled for other beneficial applications such as vapor generation. This all makes it a very effective Waste-to-Energy Process.

The inorganic fraction can be classified as a non-hazardous material and can be beneficially reused in most cases.

Technologies we apply here:

Pyrolysis
Thermal Desorption

Additional services we offer here:

- Design Build Operate Maintain (DBOM model)
- Plant Management
- Process efficiency consultancy
- Pilot Plant testing
- Laboratory analysis’s & consultancy
- Feasibility studies
Drilling Mud Treatment

Oil-based mud is characterized by hydrocarbon contamination. In some cases, this kind of contamination is controlled by means of lagoon storage, otherwise known as Biopile, in which contaminants are biologically degraded by microorganisms. However, the use of the Biopile can be counterproductive since bio-remediation in an almost water-free environment is nearly negligible and hydrocarbon removal is mostly due to the evaporation of lighter fractions which can contribute to atmospheric pollution. Other techniques can also be used to manage hydrocarbon contamination but these are only scarcely sustainable from an economic and environmental point of view.

3V Green Eagle developed an environmentally and economically sustainable solution for the treatment of mud contamination via thermal desorption. The solution proposed is competitive with respect to other existing technologies, in particular hydrocarbon extraction via solvent application and recovery, or via mechanical centrifuging.

What we offer:

The solution proposed by 3V Green Eagle for the treatment of “fresh” mud allows a dry solid to be obtained, which is suitable for road construction, and an oily residue to be created that can be reused or burned. In case of “older” mud beyond the dry residue, the liquid residue can also be recovered and reused.

Technologies we apply here:

- Oil & Solvent recovery
- Thermal Desorption

Additional services we offer here:

- Design Build Operate Maintain (DBOM model)
- Process efficiency consultancy
- Pilot Plant testing
- Laboratory analysis’s & consultancy
- Feasibility studies
OUR TECHNOLOGY PORTFOLIO

- **TOP®**: Wet Air Oxidation for Spent Caustic
- **TOP®**: Wet Oxidation for Wastewater
- **TOP®**: Wet Oxidation for Sludge
- **DUAL TOP®**: Wet Oxidation for Sludge and Wastewater Combined
- **PYROLYSIS**: Soil and Sediment Washing
- **OIL & SOLVENT RECOVERY**: Oil & Solvent Recovery
- **ZERO LIQUID DISCHARGE (ZLD)**: Wastewater Concentration and Drying
- **PHYSICAL CHEMICAL TREATMENT**: Enhanced Biological Treatment
- **THERMAL DESORPTION**: Pyrolysis
- **SOIL AND SEDIMENT WASHING**: Soil and Sediment Washing
- **WASTEWATER CONCENTRATION AND DRYING**: Wastewater Concentration and Drying

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TOP®
WET OXIDATION

Thanks to the interdisciplinary skill of its personnel, 3V Group developed the TOP® - Wet Oxidation for Wastewater technology, a cutting-edge wet oxidation process used for the treatment of:

- Industrial wastewater, using TOP® - Wet Oxidation for Wastewater
- Industrial or Sewage Sludge, using TOP® - Wet Oxidation for Sludge
- Industrial Wastewater and Sludge Combined, using DUAL TOP® - Wet Oxidation for Wastewater & Sludge combined

TOP® - Wet Oxidation technologies have the following main features:

- Allows dissolved compounds to burn in water (flameless). Under dry conditions, such compounds would oxidize at much higher temperature and pressure;
- Allows total chemical compounds destruction (99.9%);
- Reduces COD content by 70% and makes the remaining 30% highly biodegradable, by demolishing complex molecules into simple molecules and therefore transforming 100% non-biodegradable waste into highly biodegradable waste.

THIS TECHNOLOGY HAS THE FOLLOWING CHARACTERISTICS

PRESSURE 150 BAR | TEMPERATURE 300°C | OXYGEN PRESSURE
TOP® technology can be implemented on industrial scale with the following main features:

1. Continuous operation
   Operations are performed on a continuous 24 hours cycle. There are no. 2 scheduled stops per year (usually one in summer and one in winter)
   Scheduled management of maintenance.
   Possibility of installing multiple modular “parallel” systems, to ensure operations also during any intervention of longer duration

2. Highly automated
   Single Operator in Control Room
   Automation based on DCS technology

3. Low utilities consumption
   Electric Power:
   Electrical consumption is mainly related to electrical pumps for oxygen injection and liquid waste pumping into the process
   Thermal Power:
   Provided by the combustion process, depending on COD of the incoming stream
   Process Heat is recovered to dry the inorganic fraction

4. Modularity
   The architecture of the process allows for easy expandability of the plant capacity through installation of new Process modules that provide:
   · Increasing plant capacity without interrupting the treatment activity
   · The optimal management of spare parts
   · Keeping a compact layout that minimizes the cost of revamping

5. Flexibility
   Treatment of almost unlimited quantity of different streams.
**SOME RELEVANT STUDY RESULTS**

**TOP⁺ - Wet Oxidation for Wastewater has a high performance long track record on a wide variety of waste streams:**

<table>
<thead>
<tr>
<th>WASTEWATER</th>
<th>ACTIVE PRINCIPLE (or critical state)</th>
<th>ACTIVE PRINCIPLE REDUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colours</td>
<td>APHA Colour</td>
<td>&gt;99.9%</td>
</tr>
<tr>
<td>Detergents</td>
<td>MBAS-TAS</td>
<td>&gt;99.9%</td>
</tr>
<tr>
<td>Pharmaceutical (antibiotics: Tetracycline)</td>
<td>BOD/COD = 0.02</td>
<td>BOD/COD = 0.69</td>
</tr>
<tr>
<td>Fine Organics (Waters from nitration)</td>
<td>NITRO-CRESOL</td>
<td>98.4%</td>
</tr>
<tr>
<td>Fine Organics (phenolic resins)</td>
<td>APHA Colours-phenols</td>
<td>96.5% - 99.9%</td>
</tr>
<tr>
<td>Fine Organics (maleic dioxide)</td>
<td>COD</td>
<td>67%</td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td>Cyanides</td>
<td>&gt;99.9%</td>
</tr>
<tr>
<td>Reclamation (draining off water from piezometers)</td>
<td>Chlorinates</td>
<td>&gt; 87.5%</td>
</tr>
</tbody>
</table>

**Residual COD - Organo-chlorinated reduction is also significant:**

<table>
<thead>
<tr>
<th>TEST</th>
<th>BEFORE WET OXIDATION</th>
<th>AFTER WET OXIDATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>n°</td>
<td>Binary</td>
<td>pH in</td>
</tr>
<tr>
<td></td>
<td>Chlorides</td>
<td>mg/l</td>
</tr>
<tr>
<td>837</td>
<td>70</td>
<td>11.6</td>
</tr>
<tr>
<td>838</td>
<td>92</td>
<td>11.6</td>
</tr>
<tr>
<td>828</td>
<td>3500</td>
<td>12.6</td>
</tr>
<tr>
<td>830</td>
<td>3500</td>
<td>12.6</td>
</tr>
<tr>
<td></td>
<td>1,2 Dichloroethylene</td>
<td>pH in</td>
</tr>
<tr>
<td>833</td>
<td>89</td>
<td>11.4</td>
</tr>
<tr>
<td>834</td>
<td>94</td>
<td>11.4</td>
</tr>
<tr>
<td>822</td>
<td>3500</td>
<td>12.7</td>
</tr>
<tr>
<td>821</td>
<td>3500</td>
<td>12.7</td>
</tr>
</tbody>
</table>
Micro-Pollutants Reduction:
From 415 to 84 nanogram/kg. Equivalent toxicity reduction by 80%.

<table>
<thead>
<tr>
<th></th>
<th>Sample in</th>
<th>Sample out</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ph</td>
<td>7.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>kg/L</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td>Chlorides</td>
<td>mg/L</td>
<td>27,000</td>
<td></td>
</tr>
<tr>
<td>COD</td>
<td>mg/L</td>
<td>25,200</td>
<td>6,850</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>mg/kg</td>
<td>543</td>
<td>110</td>
</tr>
<tr>
<td>IPA</td>
<td>mg/kg</td>
<td>&lt; 0.1</td>
<td></td>
</tr>
<tr>
<td>PCB</td>
<td>mg/kg</td>
<td>&lt; 0.1</td>
<td></td>
</tr>
<tr>
<td>Dioxins</td>
<td>nanog/kg</td>
<td>415</td>
<td>84</td>
</tr>
<tr>
<td>Residue at 105° C</td>
<td>%</td>
<td>28.3</td>
<td>27.7</td>
</tr>
<tr>
<td>Residue at 555° C</td>
<td>%</td>
<td>24.3</td>
<td>24.8</td>
</tr>
</tbody>
</table>
**TOP® is environmentally sustainable**

1. Extremely low exhaust emissions (CO₂)

   - The Wet Oxidation process produces low temperature (40-60 °C) gaseous emission (about 10-12% by mass with respect to an incinerator). Reaction gases are cooled and washed, the incondensable gases are burned in a heater. Gas emission from TOP® plant are very low, since the gases discharged are substantially carbon dioxide produced during the reaction and oxygen fed in excess with respect to the COD converted.

2. No harmful emissions

   - The gases discharged by the plant are only carbon dioxide produced during the reaction and oxygen fed in excess with respect to COD converted. The reaction gases are cooled and washed before leaving the oxidation plant. Reaction conditions (temperature, pH, etc.) do not allow the formation of any hazardous substances (eg. Dioxins).

3. No fly ashes

   - Unlike incineration, TOP® - Wet Oxidation process operates at much lower temperatures and in aqueous medium; the inorganic residue leaves the plant suspended in the liquid effluent and it is recovered by conventional decantation and filtration.

   TOP® - Wet Oxidation does not require any treatment of gas emissions and does not generate any hazardous solids “gas suspended” to be disposed of through special landfills (fly ash).

4. High degradation of organic substances

   - High degradation of organic substances either dissolved or suspended. Liquid effluent totally biodegradable.

**Biodegradability of residual COD:**

Example of wastewater coming from nitration of aromatic compounds.

5. Oxidation and stabilization of heavy metals

   - The metals contained in the feeding (no other metals are added such as catalysts for example), at the operating conditions of the process, precipitate as oxides, so the content of such metals in the liquid effluent is drastically reduced.
6. Inorganic residue (TOP® Filler) reuse for industrial and civil construction applications

- Inorganic residue of Wet Oxidation treatment becomes TOP® Filler, a raw material that can be used to build roads.

Spherapor is a Lightening Structuring material; it is characterized by an open porosity almost nothing as the surface of the sphere shows vitrified. This feature prevents water absorption, whatever the application in which Spherapor is used, thus ensuring the high lightness of the final product. Mechanical strength up to 5 times higher than that of the reference products on the market it is combined with the low specific gravity; lightness and mechanical strength, as well as a very high chemical inertness, make Spherapor a highly innovative solution for Lightweight Concrete, or Glue, markets particularly for the building field.

In 2013 such solid residue obtained the CE mark to be used as filler for bituminous materials and similar.
Comparison between TOP® - Wet Oxidation and other technologies for sludge treatment

**WET OXIDATION**
- **RECOVERY**: 100% RECOVERY
- **SUSTAINABILITY**: 0% TO LANDFILL
- **ENVIRONMENTAL IMPACT**: ZERO DISCHARGE
- **COMPLIANCE WITH BEST PRACTICES**: INORGANIC FRACTION REUSE

**DEHYDRATION + LANDFILL DISPOSAL**
- **RECOVERY**: 25% RECOVERY
- **SUSTAINABILITY**: 75% TO LANDFILL
- **ENVIRONMENTAL IMPACT**: LARGE FOOTPRINT AND LEACHATE PRODUCTION
- **COMPLIANCE WITH BEST PRACTICES**: ENERGY RECOVERY

**DRYING + INCINERATION**
- **RECOVERY**: 73% RECOVERY
- **SUSTAINABILITY**: 3% TO LANDFILL
- **ENVIRONMENTAL IMPACT**: POTENTIAL GASEOUS EMISSIONS AND ASHES TO LANDFILL
- **COMPLIANCE WITH BEST PRACTICES**: BIOGAS PRODUCTION

**ANAEROBIC DIGESTION**
- **RECOVERY**: 75% RECOVERY
- **SUSTAINABILITY**: 25% TO LANDFILL
- **ENVIRONMENTAL IMPACT**: POSSIBLE ODOR ISSUES
- **COMPLIANCE WITH BEST PRACTICES**: BIOGAS PRODUCTION

Source: Bain&Co.
Assumptions: 65% Sludge from Anaerobic digestion sent to Agriculture; 2.5 inlet sludge solid

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Whereas:
Chemical-Physical water treatment usually transfers contaminants from wastewater to wastewater sludge
• Biological process is not adequately effective on high C.O.D. waters, and does not allow destruction of complex chemical, toxic or recalcitrant compounds (biologic reactors, anaerobic digestors)
• Besides solvent-rich streams, incineration is not cost effective on liquid waste with moderate to high water content. In addition to air emission and fly ash, incineration can also produce additional contaminants (dioxins and other micro-pollutants)
• Sludge disposal to Landfill or Agriculture does not provide a sustainable long-term solution.

TOP® - Wet oxidation technology allows total chemical compounds destruction.
The first industrial plant - “the Multipurpose TOP®”, launched in 1984 at the 3V Chemical Plant in Mozzo (BG), Italy, and has the capacity to treat 5 m³/h of mixed industrial wastewater with an organic load of 50,000 mg/l of C.O.D., achieving a reduction of around 80%.

A second mixed industrial plant - another “Multipurpose TOP®” started running in 1990 within the Grassobbio treatment center in Bergamo Italy and was initially designed to treat up to 12 m³/h, then was upgraded to treat 15 m³/h. This plant treats waste with an organic load of up to 60,000 mg/l of C.O.D, achieving reductions that range (depending on the fed type of waste) from 75% to 85%.

A third plant, launched in January 1995, is a “Class B Dedicated TOP®” in Porto Marghera (VE), Italy, treating wastewater generated by the nitrification of toluene. The plant treats up to 2 m³/h of liquid with a C.O.D. load of around 20,000 mg/l, achieving a reduction of more than 80%.

TOP® technology has already received international awards

- 1990 Best Reparative Technology award from ENEA (the EU delegate for Italy)
- 2006 BAT (Best Available Techniques) award from the EU-IPPC for O.F.C.s (Organic Fine Chemicals).
Our TOP® - Wet Air Oxidation technology for Spent Caustic:

- Has been extensively tested on an industrial scale.
- Is able to reduce COD levels by approximately 70%. The remaining COD is detoxified, fully decolored and almost entirely biodegradable, allowing it to be further processed in a biological plant.

Wet Air Oxidation is a proven technology currently being used by numerous olefin plants.

Spent caustic liquors from ethylene manufacturing and petroleum refining are some of the nastiest wastewater the industry must deal with. These liquors are odorous, highly colored and contain sodium sulfides, mercaptans, phenols and emulsified hydrocarbons, so they do not respond to traditional treatment.

The most effective on-site treatment of spent caustic is TOP® - Wet Air Oxidation for Spent Caustic which can achieve the oxidation of pollutants as sulfide to soluble thiosulfate, sulfate and sulfite. The treated stream is then suitable for bio treatment in the plants wastewater treatment system.

The TOP® technology is best known for treating liquid wastes in the following manner:

- During the wet phase heavy organic molecules are oxidized by air at high temperature and high pressure levels creating a process similar to a flame less burning.
- Complex organic molecules are oxidized and become simple, biodegradable molecules.
- Odor and color will be permanently removed.
TOP® SPENT CAUSTIC PROCESS FLOW

Solutions that use this technology include:
- Wastewater Treatment
- Wastewater & Sludge Treatment
- Liquid Off-Spec Product Treatment

SPENT CAUSTIC STREAM → TOP® → REACTION GAS → OFF-GAS TREATMENT

ADDITIVES → AIR → POWER (kW) → GAS or HPS

LIQUID EFFLUENT → BIOLOGICAL TREATMENT
TOP® - WET OXIDATION FOR WASTEWATER

TOP® - Wet Oxidation for wastewater represents the first breakthrough in applying the TOP® - Wet Oxidation technology on an industrial level.

This technological innovation has been found to be the best available technique in the treatment of wastewater according to the EU-IPPC for Organic Fine Chemicals.

Implementation on an industrial scale

The TOP® - Wet Oxidation technology for wastewater has been extensively tested on an industrial scale ever since 1990 and represents the only technology which is capable of treating a wide variety of industrial, complex third party waste streams on a global scale.

TOP® Wastewater is able to reduce COD levels by approximately 70%. The remaining COD, following the treatment, is detoxified, fully decolored and almost entirely biodegradable, allowing it to be further processed in a biological plant.

Further it eliminates almost all of the organic fraction and produces a stable, inorganic material that is rich in calcium and phosphorous. This material can also be reused as a primary-secondary material. In 2013, our solid residue obtained the CE mark which allows it to be used as a filler for bituminous materials and similar matters.

The TOP® technology is best known for treating wastes in the following manner:

- Heavy organic molecules are oxidized by pure oxygen or air in the wet phase at high temperatures and high pressure levels
- Complex organic molecules (which, under normal circumstances, are not biodegradable) are oxidized and become simple, biodegradable molecules such as carbon dioxide and water.

The applications for the TOP® - Wet Oxidation for wastewater include:

- The treatment of mixed industrial wastewater from multiple sources of organic production with a COD level of between 20,000 and 100,000 mg/L. The treatment can reduce the organic load between 80% and 95%. In such cases, the technology (referred to as “Multi-Stream TOP®”) requires the use of oxygen as the oxidizing agent, and special super-alloys for the construction of the system.
- The treatment of industrial wastewater from a single source of production (referred to as “Single-Stream TOP®”). Systems of this type are relatively simple. In general, the type of material required and the oxidant, either oxygen or air, are decided on a case-by-case basis.
Solutions that use this technology include:

- Wastewater Treatment
- Wastewater & Sludge Treatment
- Liquid Off-Spec Product Treatment
3V Green Eagle’s TOP® - Wet Oxidation for Sludge technology can achieve:

- A significant reduction in sludge volume
- The stabilization of sludge and dissolved metals
- The removal of the microbial load
- The partial or full mineralization of the sludge
- A zero discharge process without the use of hazardous gases

Applications:

The TOP® - Wet Oxidation for Sludge technology is able to treat sludge produced by biological systems at diverse operating conditions.

- 2-3% in solid, directly following aerobic or anaerobic digestion and sent to TOP® via pipe
- 15-25% in solid, after filter-pressing or centrifuging and sent to TOP® via truck or train

Therefore, the TOP® - Wet Oxidation for Sludge can be installed at:

- Large municipal facilities in order to treat sewage sludge produced by large biological plants.
- Large industrial parks with multiple industries performing wastewater pre-treatment, generating large quantities of sludge following physical-chemical-biological treatment.

Our TOP® - Wet Oxidation for Sludge technology can achieve the following:

The organic fraction constituted by volatile solid substances can be eliminated by up to 96%. This means that our technology has the capacity to almost entirely eliminate organic substances. The operating conditions, including temperature and pressure, are more moderate and safer than those used for the TOP® - Wet Oxidation for wastewater technology.

The TOP® unit effluent is sent to the biological plant for final treatment. A zero discharge process is established which does not produce any solid waste and no air emissions. This treatment process can eliminate almost all of the organic fraction which produces a stable, inorganic material that is rich in calcium and phosphorous. This material can also be reused as a primary-secondary material. In 2013, our solid residue obtained the CE mark which allows it to be used as a filler for bituminous materials and similar matters.
Solutions that use this technology include:

- Sludge & Sewage Treatment
DUAL TOP® - WET OXIDATION FOR SLUDGE & WASTEWATER COMBINED

3V Green Eagle’s Dual TOP® - Wet Oxidation technology for sludge and wastewater combined allows the simultaneous treatment of:

- Activated sludge from biological plants in the industrial or civil industry
- Industrial wastewater
- Landfill leachates with high COD levels
- Highly contaminated sediments (marine, fluvial, etc)
- Other liquid or wastewater streams which can be pumped.

**Applications**

The TOP® - Wet Oxidation for Sludge technology is able to treat sludge produced by biological systems at diverse operating conditions.

- 2-3% in solid, directly following aerobic or anaerobic digestion and sent to TOP® via pipe.
- 15-25% in solid, after filterpressing or centrifuging and sent to TOP® via truck or train.

Therefore, the TOP® - Wet Oxidation for Sludge can be installed at:

- Large municipal facilities in order to treat:
  - Sewage sludge produced by large biological plants
  - Industrial wastewater produced by industrial areas or point-source industries
- Large industrial parks with multiple industries performing wastewater pre-treatment, generating both:
  - Large quantities of sludge following physical-chemical-biological treatment; and
  - Large quantities of wastewater or off-specification products.

**Implementation on an industrial scale**

The Dual TOP® technology has the capacity to:

- Treat a mix of industrial wastewater, sludge and/or port sediments with a COD between 20,000 and 100,000mg/L. In addition, it is able to degrade more than 99.9% of pollutants which are present.
- Reduce the COD of the sludge/water mix up to 85%
- Reduce volatile suspended solids contained in the sludge by 96% to 98%
- Recover heat from the oxidation process to dry the inorganic residue output
- Maintain more moderate and safer operating conditions, including temperature and pressure, than those used for the TOP® - Wet Oxidation for wastewater technology.
- Establish a zero discharge process which does not produce any solid waste and no air emissions
- Eliminate almost all of the organic fraction which produces a stable, inorganic material that is rich in calcium and phosphorous. This material can also be reused as a primary-secondary material. In 2013, our solid residue obtained the CE mark which allows it to be used as a filler for bituminous materials and similar matters.
DUAL TOP® SLUDGE & WASTEWATER PROCESS FLOW

Solutions that use this technology include:
- Wastewater Treatment
- Wastewater & Sludge Treatment
- Soil & Sediment Treatment
- Liquid Off-Spec Product Treatment
The effluent from our Wet Oxidation plants act as a source of carbon for the denitrification process in the MBR. Not only is this effluent efficiently used from biomass, it allows high speed biological denitrification to occur.

The final process of the DUAL TOP® - Wet Oxidation treatment includes the further removal of micro pollutants which can potentially be adsorbed in the sludge from the MBR system. This step is essential in preventing the release of recalcitrant contaminants into the environment.

All of the above allows us to treat incoming industrial waste water with excellent removal efficiencies at all the required parameters set by our clients.
Solutions that use this technology include:

- Wastewater Treatment
- Sludge & Sewage Treatment
- Wastewater & Sludge Treatment
Solutions that use this technology include:

- Wastewater Treatment
- Sludge & Sewage Treatment
- Wastewater & Sludge Treatment
Physical-chemical treatment can often act as a stand-alone process for treating wastewater with heavy metals and low concentrations of organic pollutants. If high concentrations of organic pollutants are present, however, Wet Oxidation treatment is required in order to achieve a zero discharge process.

Combined with the TOP® - Wet Oxidation treatment, a physical-chemical unit allows the removal of the oxidized inorganic fraction. The residual is defined by 3V Green Eagle as “TOP Filler” and it can be reused for road construction. Our TOP Filler has obtained a CE certificate.

3V Green Eagle has gained extensive experience in physical-chemical unit management as this has been implemented at our treatment center in Italy. It is used to perform pre- and post-treatment activities for the Wet Oxidation process and biological plant treatment.

Physical-chemical treatments are most commonly known as physical sedimentation processes accelerated with flocculants and coagulants. Mild oxidation can sometimes be integrated in this process as well.
WASTEWATER CONCENTRATION

Disposal firms and companies which utilize water in manufacturing processes must separate water from contaminants before discharging or reusing it in further processes.

3V Green Eagle employs evaporation technologies which have characteristic advantages on waste water concentrations:

- Volume reduction of the effluent can be maximized with a water content of up to 1-3% of water content. This results in low disposal costs.
- Valuable substances can be recovered in the concentrate.
- The condensate, otherwise known as distillate, can be recycled as process water.
- It requires negligible uses of chemical substances.

Our evaporation systems commonly operate under vacuum and can be designed for single-duty or multi-purpose operation. They optimally combine the following technologies:

ENERGY SAVING

3V Green Eagle always tries to apply techniques which minimize energy consumption for its evaporation plants. Some of the methodologies we apply include:

- Multiple effect arrangement (ME)
- Thermal vapor recompression (TVR)
- Mechanical vapor recompression (MVR)
- Usage of waste energy

Falling Film Evaporators

This technology is particularly suited for energy-saving, multiple-effect evaporation and mechanical vapor re-compression processes. It only requires a very small operating temperature and thus allows it to be easily controlled and fast to start up and shut down due to a minimal liquid hold-up. Falling film technology is the right solution for streams which are viscous in nature and contain small concentrations of suspended solids. A falling film evaporator can be used as a pre-concentrator in a combined multiple-effect plant. It has the capacity to treat streams with small to large flow rates.

Thin Film Evaporators/Dryers

These devices are mostly used when strong sludge dewatering or drying is required. They can be used to achieve a water content of less than 5%. Like the falling film evaporators, this technology is easy to control and fast to start up and shut down due to a very low liquid hold-up. Thin film technology is the right solution for scaling products and for highly viscous fluids. A thin film evaporator can be used as a high-concentrator in a combined multiple-effect plant. It has the capacity to treat streams with small to medium flow rates.

Forced Circulation Evaporators

Due to the high circulation flow-rate and evaporation external to the heat exchanger, forced circulation technology is the right solution for highly viscous streams containing a large concentration of suspended solids, fouling products. A forced circulation evaporator can be used as a high-concentrator in a combined multiple-effect plant. It has the capacity to treat streams with medium to large flow rates.
Solutions that use this technology include:

- Wastewater Treatment
- Sludge & Sewage Treatment
- Oil & Solvent Treatment
- Liquid Off-Spec Product Treatment
Solutions that use this technology include:

- Wastewater Treatment
ZERO LIQUID DISCHARGE (ZLD)

Zero Liquid Discharge (ZLD) is an industrial process which does not release any wastewater. This target is commonly achieved by separating streams into evaporation or crystallization paths. During these processes, contaminated elements are discharged as solid waste whilst the condensate is recovered. Typically, the effluent is a salty solution and the thermal separation is the final step of ZLD, after being exposed to pre-treatments, ultrafiltration and reverse osmosis units.

ZLD technology has characteristic advantages on wastewater concentrations:

- No wastewater discharge leaves the plant. Only solid wastes are produced and they are disposed of appropriately.
- Volume reduction of the effluent can be maximized with a water content of up to 1-3% of water content. This results in low disposal costs.
- The condensate, otherwise known as distillate, can be recycled as process water.

Our evaporation and crystallization systems commonly operate under vacuum and can be designed for single-duty or multi-purpose operation. They optimally combine the following technologies:

**Falling Film Evaporators**

This technology is particularly suited for energy-saving, multiple-effect evaporation and mechanical vapor re-compression processes. It only requires a very small operating temperature and thus allows it to be easily controlled and fast to start up and shut down due to a minimal liquid hold-up. Falling film technology is the right solution for streams which are viscous in nature and contain small concentrations of suspended solids. A falling film evaporator can be used as a pre-concentrator in a combined multiple-effect plant. It has the capacity to treat streams with small to large flow rates.

**Thin Film Evaporators/Dryers**

These devices are mostly used when strong sludge dewatering or drying is required. They can be used to achieve a water content of less than 5%. Like the falling film evaporators, this technology is easy to control and fast to start up and shut down due to a very low liquid hold-up. Thin film technology is the right solution for scaling products and for highly viscous fluids. A thin film evaporator can be used as a high-concentrator in a combined multiple-effect plant. It has the capacity to treat streams with small to medium flow rates.

**Forced Circulation Evaporators**

Due to the high circulation flow-rate and evaporation external to the heat exchanger, forced circulation technology is the right solution for highly viscous streams containing a large concentration of suspended solids, fouling products. A forced circulation evaporator can be used as a high-concentrator in a combined multiple-effect plant with a mechanical vapor recompression arrangement. It has the capacity to treat streams with medium to large flow rates.

**ENERGY SAVING**

3V Green Eagle always tries to apply techniques which minimize energy consumption for its evaporation plants. Some of the methodologies we apply include:

- Multiple effect arrangement (ME)
- Thermal vapor recompression (TVR)
- Mechanical vapor recompression (MVR)
- Usage of waste energy
OIL & SOLVENT RECOVERY

As numerous industrial processes require the minimization of wastewater and the recovery of the reusable fractions, evaporation, stripping and distillation techniques play an important role in the manufacturing industry as well as in the field of environmental technology.

Our systems are designed to recover solvents from effluent streams. They are then cleaned and prepared for reuse and/or purification so that the liquid stream does not contain any volatile products for further processing.

ENERGY SAVING

3V Green Eagle always tries to apply techniques which minimize energy consumption for its evaporation plants. Some of the methodologies we apply include:

- Multiple effect arrangement (ME)
- Thermal vapor recompression (TVR)
- Mechanical vapor recompression (MVR)
- Usage of waste energy

Our systems commonly operate under vacuum and can be designed for single-duty or multi-purpose operation. They optimally combine the following technologies:

**Stripping by Steam or Other Gas**

This technique removes VOC, ammonia and similar substances from liquid streams. Stripping can either be carried out in a structured column, a randomly packed column, or a trayed column.

**Distillation**

This technique is used to separate compound mixtures under pressurized or vacuum conditions. Columns are the core of distillation plants and can be equipped with different kinds of internals, depending on the type of application. These may include a sieve tray, a bubble cap tray, structured packing or a tunnel cap tray.

**Falling Film Evaporators/Reboilers**

This technology is mostly used for temperature-sensitive products. It is particularly suited for energy-saving, multiple-effect evaporation and mechanical vapor recompression processes. It only requires a very small operating temperature and thus allows it to be easily controlled and fast to start up and shut down due to a minimal liquid hold-up. Falling film technology is the right solution for streams which are viscous in nature and contain small concentrations of suspended solids. It has the capacity to treat streams with small to large flow rates.
Thin Film Evaporators/ Reboilers

With the optimal combination of vacuum and temperature conditions and the spreading action of the internal rotor, this technology is mostly used for products with an extremely high heat-sensitivity. It is also used for the purification of substances with a very high boiling point. This technology is easy to control and fast to start up and shut down due to a very low liquid hold-up. Thin film technology is the right solution for scaling products and for highly viscous fluids. It has the capacity to treat streams with small to medium flow rates.

Solutions that use this technology include:

- Wastewater Treatment
- Wastewater & Sludge Treatment
- Oil & Solvent Treatment
- Drilling Mud Treatment
- Liquid Off-Spec Product Treatment

Forced Circulation Evaporators/ Reboilers

Due to the high circulation flow-rate and evaporation external to the heat exchanger, forced circulation technology is the right solution for highly viscous streams containing a large concentration of suspended solids, fouling products. It has the capacity to treat streams with medium to large flow rates.
SOIL & SEDIMENT WASHING

3V Green Eagle in collaboration with TREVI created the company 6V to optimize the performance of land reclamation and environmental restoration works mainly through on-site techniques, including the management, treatment and recovery of contaminated soils and sediments - within infrastructural works - land reclamation works and confinement of polluted sites.

The management of contaminated soils and sediments has gained increasing importance in recent years. Decades of industrial management with a lack of environmental awareness and appropriate regulations have created largely polluted areas requiring urgent environmental attention.

Additionally, the issues concerning the management of sediments resulting from activities involving drainage maintenance and reclamation strongly affect the development of many Italian ports and harbors, some of which are located within the Contaminated Sites of National Interest.

Contaminated soil and sediment dredged from ports or access channels require specific treatment technologies in order to be re-used in a sustainable way. These treatment technologies often require the following steps:

- Decontamination
- Minimization of volumes intended for treatment
- Maximum product re-use

Dredged Sediment Management Approach:

- For non-contaminated sediment:
  - Maximize sediment reuse via grain size separation techniques such as sand and gravel recovery (vibro-sieving)
  - Achieve silt geotechnical stabilization for recycle:
    - In line thickening process (centrifuge)
    - In line consolidation process (adding binders)

- For contaminated sediment:
  - Maximize sediment reuse via grain size separation techniques such as sand and gravel recovery (vibro-sieving)
  - Send the suspension of silt and process water to the TOP® - Wet Oxidation treatment plant.

Treatment Plant Capabilities:

3V Green Eagle’s treatment plant has the following features:

- Physical forces wash contaminants and fines from the coarse fraction.
- Piles of coarse-grained material are generated for re-use. A fluid stream containing silt and clay is also produced and requires further handling.
- The plant handles large fluidized inputs in large amounts (systems designed for 350-400 m3/h input).
- It works automatically in small spaces.
- A batch-specific cement grout is injected directly at the centrifuge input. The quantity of binders added is automatically controlled based on sensors that measure the inlet mud flow rate and density.
- Customization, homogeneity and quick hardening allow for immediate disposal, reuse or recycling without the need for storage or drying.
Technological Applications and References:

- In order to thoroughly study and test different problems concerning soil and sediment washing, 3V Green Eagle uses pilot plants. Some interesting tests that were performed for public entities include the following:

- In 2011, the Surveyor for the Social, Economic and Environmental Emergency who is concerned with the major navigation port canals of the Venice Lagoon (Commissario Delegato per l’Emergenza Socio Economico Ambientale relativa ai Canali Portuali di Grande Navigazione della Laguna di Venezia) has authorized the testing of an innovative process for the treatment of dredged sediments. It also includes the stabilization of the dredged sediment’s fine fraction through the continuous injection of cement grout, so as to enhance its mechanical features before the final disposal. The testing procedure consists in draining and subsequently treating 200 m³ of sediments coming from different areas within the canals of Porto Industriale di Marghera. Experimental Design were presented at the 7th International Conference on Contaminated Sediment Remediation in February 2013.

- In 2013, we conducted a similar case study on the Livorno and La Spezia ports (Italy) commissioned by Sogesid, a company owned by the Italian environmental minister.

Solutions that use this technology include:

- Soil & Sediment Treatment
PYROLYSIS
A chemical reaction initiated by molecular breakdown at high temperature.

Pyrolysis is defined as the endothermic decomposition of a condensed substance by the action of heat. This technique does not involve reactions with oxygen or any other reagents, however, it may be conducted in their presence.

The pyrolysis technology differs from incineration because:

- It is an endothermic reaction which absorbs heat. Combustion, on the other hand, is an exothermic reaction which releases heat.
- It occurs in the presence of an insignificant amount of oxygen. Incineration, on the other hand, requires a significant amount of oxygen or air.
- Pyrolysis needs a continuous external energy source.

3V Green Eagle has developed pyrolysis applications for industrial waste, sludge, tars and refinery waste. It is ideal for waste types that currently have limited options for treatment or disposal.

Solutions that use this technology include:
- Liquid Off-Spec Product Treatment
- Tar & Pitch Treatment
THERMAL DESORPTION
For oil based mud

The drilling of mud represents an ongoing challenge for oil and gas companies. Along with increased environmental awareness, more stringent environmental regulations and the rising cost of oil, new technologies are always required which recover the oil fraction contained in the mud produced during drilling operations.

Standard technologies such as mechanical separation are not able to achieve stringent recovery standards in most cases. For example, it does not have the capacity to recover oil if the oil content in mud is less than 5%. Thermal separation technologies and thermal desorption represent an ideal solution as they can achieve a residual oil content of up to 1%. It should be noted, however, that standard thermal desorption technologies might encounter some limitations due to viscosity and solid content. Thin film evaporators (TFE) are also an ideal application.

3V Green Eagle and 3V Tech* developed significant experience in TFE applications for environmental solutions.

Solutions that use this technology include:
- Oil & Solvent Treatment
- Soil & Sediment Treatment
- Drilling Mud Treatment
- Liquid Off-Spec Product Treatment
- Tar & Pitch Treatment

SUPPLY OF **TURN-KEY PLANTS**
**DBOM MODEL**
SUPPLY OF TURN-KEY PLANTS

**DBOM MODEL**

**DESIGN, BUILD, OPERATE, MAINTAIN**

The DBOM model is a very efficient solution where only one company is in charge of design, construction and operation of a treatment plant, therefore creating faster and more cost-efficient project delivery.

3V Green Eagle, being part of 3V group, which has almost 60 years of experience in advanced chemical engineering and manufacturing process systems & equipment, has the unique possibility to be a single-source, full service partner for all of it’s clients. We can design and implement complete process systems with all of the necessary technology and manufacturing expertise drawn from within our group.

Where our competitors are only able to offer a single service or system, we can offer the complete system with full service.

This type of approach is increasing in popularity because in comparison to traditional project delivery methods, the process of integrating three functions into one project allows more to be accomplished, while also creating the simplicity of dealing with only one entity throughout the life of the project. Removing the complexities of dealing with multiple entities.

Our sister company 3V Tech can provide a full range of engineering disciplines and has its own manufacturing facilities for the design and construction of medium and large size equipment and/or plants.

**Health & Safety**

3V Group manages its plants in compliance with the highest standards of safety and industrial working hygiene. Our origin from a large mechanical and chemical group differentiates us from any other environmental operator. Our approach to the problem of safety and intrinsic safety of the plants, designed with the highest standards on the market, makes the integrated platform a top security system.

3V Group has large expertise in the environmental field, and there are people who are concerned with safety in the chemical, mechanical and environmental fields for over decades.

The following injury rates have been obtained at 3V Green Eagle’s wastewater & sludge treatment center during the past 12 years:

<table>
<thead>
<tr>
<th>Year</th>
<th>n. of Injury</th>
<th>( I_f )</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>1</td>
<td>0</td>
<td>3 Days</td>
</tr>
<tr>
<td>2002</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>1</td>
<td>27.90</td>
<td>7 Days</td>
</tr>
<tr>
<td>2005</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>1</td>
<td>0</td>
<td>2 Days</td>
</tr>
<tr>
<td>2007</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>1</td>
<td>19.76</td>
<td>7 Days</td>
</tr>
</tbody>
</table>

\[ I_f = \frac{n.\ injuries \times 1.000.000}{\text{worked hours}} \]

**NOTE:** calculation contributes exclusively accidents with prognosis to refrain from work for more than 3 days.

Accident prognosis outlined on the left, are listed on the register of injuries, but are not reported to the authorities (according to Italian regulations) and therefore do not contribute to the calculation of the above parameters.
3V GREEN EAGLE

SUPPLY OF TURN-KEY ENVIRONMENTAL PLANTS

OUR SISTER COMPANY 3V TECH CAN PROVIDE A FULL RANGE OF ENGINEERING DISCIPLINES AND HAS ITS OWN MANUFACTURING FACILITIES FOR THE DESIGN AND CONSTRUCTION OF MEDIUM AND LARGE SIZE EQUIPMENT AND/OR PLANTS.

Manufacturing facilities with:

• 3D design systems
• In house engineering
• In house quality control
• High capacity cranes
• In house calendering, machining, welding
• Easy access to transport infrastructure

3V Tech operations has an overall capacity of 100,000 manhours/year:

• Project Management
• Quality control
• Mechanical
• Electrical / Instrumentation / Automation
• Process / Research & Development
• Procurement
• Proposal
• After market

Engineering disciplines:

• Process
• Mechanical
• Electric
• Civil and structural
• Instrumentation
• Heat transfer
• Piping
• Environmental

Qualifications

• ASME (U-Stamp)
• PED / DESP
• SQL

Quality assurance

• ISO 9001

Design codes

• EN
• ISPESL
• CODAP
• ASME
• SVT
• AD 2000
KEY REFERENCES - DESIGN & BUILD

- Wastewater
- Spent Caustic
- ZLD
- Treatment

- Sludge & Sewage
  Treatment

- Oil & Solvent
  Treatment

- Soil & Sediment
  Treatment

- Drilling Mud
  Treatment

- Tar & Pitch
  Treatment
3V Group’s experience in providing environmental services for the Oil & Gas Industry. The skills matrix below summarizes the main disciplines and capabilities required to provide adequate Design, Build, Operate and Maintain (DBOM) services.

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<td>Stakeholder Engagement and Communications</td>
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</tbody>
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**KEY REFERENCES - DESIGN & BUILD**
# Wastewater - Spent Caustic - ZLD Treatment

## TOP® WET OXIDATION UNITS - REFERENCE SUMMARY

<table>
<thead>
<tr>
<th>CLIENT</th>
<th>LOCATION</th>
<th>YEAR</th>
<th>WASTEWATER TYPE</th>
<th>FLOW RATE (m³/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apital</td>
<td>Mozzo - Italy</td>
<td>1985</td>
<td>Fine Chemicals</td>
<td>4</td>
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<tr>
<td>Sigma</td>
<td>Grassobbio - Italy</td>
<td>1990</td>
<td>Fine Chemicals</td>
<td>12</td>
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<tr>
<td>3V Green Eagle</td>
<td>Grassobbio - Italy</td>
<td>2000</td>
<td>Waste Management</td>
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<tr>
<td>3V Green Eagle</td>
<td>Grassobbio - Italy</td>
<td>2010</td>
<td>Waste Management</td>
<td>2.5</td>
</tr>
<tr>
<td>CPM</td>
<td>Porto Marghera - Italy</td>
<td>1998</td>
<td>Chemicals</td>
<td>2</td>
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<tr>
<td>ORPIC</td>
<td>Sohar Refinery - Oman</td>
<td>2014</td>
<td>Spent Caustic</td>
<td>2</td>
</tr>
</tbody>
</table>

## ZLD UNITS - REFERENCE SUMMARY

<table>
<thead>
<tr>
<th>CLIENT</th>
<th>LOCATION</th>
<th>YEAR</th>
<th>WASTEWATER TYPE</th>
<th>FLOW RATE (kg/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beckaert</td>
<td>Kortijk - Belgium</td>
<td>2012</td>
<td>Nictric Acid</td>
<td>1000</td>
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<tr>
<td>SYNDIAL - ENI Group (FEED)</td>
<td>Val D'Agri - Italy</td>
<td>2013</td>
<td>Wastewater</td>
<td>1000</td>
</tr>
<tr>
<td>Qatar Gas (FEED)</td>
<td>Ras Laffan - Qatar</td>
<td>2015</td>
<td>Biological Wastewater</td>
<td>6500</td>
</tr>
</tbody>
</table>
Wastewater Treatment

Project Name
Sigma Wastewater Plant

Location, Country
Grassobbio Italy

Client
Sigma

Period
1990

Project Description
The Integrated Industrial Wastewater Treatment Center in Grassobbio was Designed & Built and currently Operated as an In-House Contract within the 3V Group. The Chemical Holding of 3V Group (3V Chemicals, formerly 3V Sigma) contracted to 3V Enterprise (Holding company of the two subsidiaries 3V Tech and 3V Green Eagle) the Design, Build, Operate and Maintain of the Center.

3V Integrated Industrial treatment center was developed from “green field”, therefore 3V has performed as Sole Contractor all necessary Civil (Foundation, structures, buildings, access roads, etc), Electrical, Mechanical, ICA & SCADA works, as well as Concept Design, Detailed Designed, Procurement and Construction Scope of Work.

The Treatment Center represents the largest environmental center for the treatment of multi-stream industrial wastewater & sludge in Italy, receiving approximately 13,000 trucks per year from more than 200 different Clients. The center is located in Grassobbio (Bergamo) and comprises waste treatment plants and service support facilities, offering final treatment at Zero Waste Discharge, treatment processes for multi-stream industrial wastewater & sludge, especially those types that are not biodegradable.

Spent Caustic Treatment

Location, Country
Sohar Refinery, Oman

Client
ORPIC

EPC
JV Petrofac (UAE) - Daelim (Korea)

Period
2014

Project Description
In September 2014, 3V was awarded by the Joint Venture (JV) between Pertofac (UAE) Daelim (South Korea) for the supply of the SPENT CAUSTIC WASTEWATER TREATMENT PACKAGE to be installed within the frame of SRIP (Sohar Refinery Improvement Project), Sultanate of Oman. The mentioned JV between Pertofac and Daelim has been awarded as EPC (Equipment & Procurement provider, Constructor) by ORPIC (Oman Oil Refineries and Petroleum Industries Company LLC) for the upgrading of the existing SOHAR Refinery configuration as well as of its capacity expansion. The spent caustic treatment is realized by means of 3V TOP Wet Oxidation technology.

Spent caustic wastewaters are generated from many industrial processes: most of them are generated by the refining of petroleum in order to remove undesired sulfur compounds from fuels. In the refining industry, the net hydrogen sulfide captured in spent caustics is too low for effective sulfur recovery in typical Sulfur Recovery Units (SRU’s), therefore the spent caustics must be disposed properly. In addition to the toxic hydrogen sulfide, both toxic mercaptans and phenolic compounds are often captured in spent caustics, severely limiting the disposal options. Due to high concentrations of toxic and smelly substances or complex molecules to destroy, traditional treatments as biological treatment or light oxidations are not effective and more severe conditions are required; wet oxidation is a proven technology currently being used by numerous petrochemical sites.

Spent Caustic wastewaters can be different in terms of contaminants (Sulfidic, Disulfidic, Mercaptanic, Phenolic, Cresylic, Naphthenic) and salinity; the plant supplied for the SRIP Project is designed, to be a multi-stream plant being able to treat a mixture of the above spent caustic wastewater types, also containing in some case high concentrations of chlorides. The Unit has a flow rate of 1.9 mc/h and serves as a sidestream Advanced Oxidation for subsequent biological treatment within Sohar Refinery.
ZLD Treatment

**FALLING FILM TRIPLE-EFFECT EVAPORATOR:** Caustic soda evaporation package for chemical company - Italy (ongoing project)

- Skid mounted plant (no. 2 skids)
- Triple effect falling film evaporator in counter-flow, heated by steam, partly operating under vacuum.
- Caustic soda concentration from 32%wt to 50%wt.

Production capacity: 34 kTPY NaOH 100%.
Evaporation capacity: approx. 5,000 kg/h.
ZLD Treatment

ZERO LIQUID DISCHARGE: Nitric acid recovery through continuous vacuum drying - Belgium (EU)

- Best suitable technology for customer selected after several tests
- No use of chemicals additive
- Recovery of heavy metals
- Nitric components re-arrangement to re-produce nitric acid from oxides

Capacity approx: 1000 kg/h
ZLD Treatment

**TRANSPORTABLE FORCED CIRCULATION EVAPORATOR AND CRYSTALLIZER:** Waste RO reject for SYNDIAL ENI Group- Italy (FEED project)

- No. 2 modules, no. 3 skids/each
- Single effect forced circulation evaporator and crystallizer, both heated by MVR (roots compressor), operating under vacuum.
- 6,200 kg/h mixed salts solution from 6%TS to salt cake < 10% residual moisture. Solid discharge by worm, screen centrifuge.

Evaporation capacity: approx. 1000 kg/h.
ZLD Treatment

FORCED CIRCULATION CRYSTALLIZER: Degremont (FEED project) for Qatargas - Qatar

- Skid mounted plant
- Single effect forced circulation crystallizer heated by hot water, operating under vacuum.

Evaporation capacity: approx. 6500 kg/h.
### OIL RECOVERY - PROJECTS OVERVIEW

<table>
<thead>
<tr>
<th>CLIENT</th>
<th>LOCATION</th>
<th>CAPACITY</th>
<th>PRODUCT</th>
<th>SCOPE OF WORK</th>
<th>YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOTULUB - Société Tunisienne de Lubrifiants</td>
<td>Bizerte, Tunisia</td>
<td>16,000 MTPY</td>
<td>Used Lube Oil Rerefining for Base Oils production</td>
<td>Expansion project, key equipment</td>
<td>2005</td>
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<tr>
<td>SIRAL/REDOIL</td>
<td>Nola, Italy</td>
<td>15,000 MTPY</td>
<td>Used Lube Oil Rerefining for Base Oils production</td>
<td>Double stages, key equipment</td>
<td>2005</td>
</tr>
<tr>
<td>GCir.GULF CHEMICALS AND INDUSTRIAL OILS CO.</td>
<td>Dammam, KSA</td>
<td>10,000 MTPY</td>
<td>Used Lube Oil Rerefining for several used</td>
<td>Single stages, key equipment</td>
<td>2003</td>
</tr>
<tr>
<td>GULF CHEMICALS AND INDUSTRIAL OILS CO.</td>
<td>Dammam, KSA</td>
<td>12,000 MTPY</td>
<td>Used Lube Oil Rerefining for several used</td>
<td>Double stages, key equipment</td>
<td>2006</td>
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<tr>
<td>ARABIAN CO. FOR OIL AND DERIVATIVES</td>
<td>Suez, Egypt</td>
<td>10,000 MTPY</td>
<td>Used Lube Oil Rerefining</td>
<td>Expansion and Upgrading</td>
<td>2007</td>
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<tr>
<td>STEE . BASE OF TECHNOLOGY FACTORY FOR RECYCLING OIL</td>
<td>Riyadh, KSA</td>
<td>30,000 MTPY</td>
<td>Used Lube Oil Rerefining for Base Oils production</td>
<td>Double stages high vacuum distillation, key equipment</td>
<td>2010 - ...</td>
</tr>
</tbody>
</table>

### SOLVENT RECOVERY - PROJECTS OVERVIEW

<table>
<thead>
<tr>
<th>CLIENT</th>
<th>LOCATION</th>
<th>CAPACITY</th>
<th>PRODUCT</th>
<th>SCOPE OF WORK</th>
<th>YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEMTEX</td>
<td>China</td>
<td>1,000 MTPY</td>
<td>Acetic acid recovery</td>
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<td>2006</td>
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<td>SPEICHI</td>
<td>Saint Vulbas, France</td>
<td>10,000 MTPY</td>
<td>Multipurpose</td>
<td>Double stages hybrid system</td>
<td>2005</td>
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<tr>
<td>OFFICINA MECCANICA SARDA</td>
<td>Cagliari, Italy</td>
<td>5,000 MTPY</td>
<td>Solvent recovery from TAR</td>
<td>Single stage vacuum distillation</td>
<td>2003</td>
</tr>
<tr>
<td>FIDON</td>
<td>Italy</td>
<td>6,000 MTPY</td>
<td>Solvent recovery from sludge</td>
<td>Single stage vacuum distillation</td>
<td>2000</td>
</tr>
<tr>
<td>Laboratori Abbot (AbbVie)</td>
<td>Campoverde, Italy</td>
<td>3,000 MTPY</td>
<td>Solvent from soil</td>
<td>Single stage vacuum distillation</td>
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<tr>
<td>PRO TEAM</td>
<td>Gela, Italy</td>
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<td>Multipurpose solvent recovery</td>
<td>Single stage vacuum distillation</td>
<td>2008</td>
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<tr>
<td>SOLVEKO</td>
<td>Fidenza, Italy</td>
<td>20,000 MTPY</td>
<td>Multipurpose solvent recovery, Expansion project</td>
<td>Hybrid Double vacuum stages</td>
<td>2009</td>
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<tr>
<td>SOLVEKO</td>
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<td>20,000 MTPY</td>
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<td>Hybrid Double vacuum stages</td>
<td>2014 - ...</td>
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<td>GLAXO WELLCOME MANUFACTURING PTE LTD</td>
<td>Singapore</td>
<td>2,000 MTPY</td>
<td>Multipurpose solvent recovery</td>
<td>Hybrid vacuum system</td>
<td>2011</td>
</tr>
</tbody>
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3V Tech's process for solvent recovery was awarded with the “Premio Impresa e ambiente award” (the Italian section of European Business award for environment) on 13 December 2012, as the best innovative process and technology, together with Solveko. The technology has been declared innovative, providing potential replication and several environmental, social, economical benefits.
Solvent Recovery

Project Name
Solvent Recovery Plant

Location, Country
Singapore

Client
GSK

Period
2011

Project Description
Solvent recovery plant for the separation and recycle of waste solvents (mainly methanol aceton, ethanol, hydrocarbons, esters...) coming from chemical, pharmaceutical industries. This plant is composed by an horizontal thin film evaporator heated by hot oil. The Thin film evaporator is used as distillation column reboiler making the process almost unaffected by the scaling problems that typically reduce the performance of the traditional heat transfer equipments, specially for plants treating wastes. The alimentation is fed to the thin film evaporator in the liquid phase; the high heat transfer rate warranted the thin film evaporator allows the evaporation of the lighter components that feed the distillation column while the heaviest components (normally the cause of the scaling issues) leave the TFE from the bottom. The vapors are rooted to the distillation column where the separation of the valuable fraction is completed. The presence of dissolved salts and acids into the alimentation has required super nickel alloys among the MOC. The Very low residence time of the product inside the TFE reduce dramatically the risk of thermal degradations or side reacation that could cause scaling (for example, polymerization).

Capacity: 0.2 m3/h
Material of construction (wetted parts): Alloy C22/AIISI 316
Heating media: Hot Oil
Operating pressure: FV ÷atm
Service: Solvent Separation, Multipurpose

<table>
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<th>High COD Wastewater Treatment</th>
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Waste Recovery via Thermal Separation

High COD Wastewater Treatment

Low COD Wastewater Treatment

Waste Treatment Center Operation & Maintenance

Environmental Engineering Design and Project Services
Solvent Treatment & Recovery

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<td>Advanced Oxidation Wastewater</td>
<td>Physical-Chemical Treatment</td>
<td>Zero Discharge Process</td>
<td>Environmental Investigation and Characterization</td>
</tr>
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<td></td>
<td>“Including Spent Caustic Wastewater treatment”</td>
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<tr>
<td>Other Separated Phase Recovery</td>
<td>Solvent Stripping</td>
<td>Enhanced Nitrification-Denitrification Process</td>
<td>Treatment Plant Feeding Optimization</td>
<td>Environmental and Waste Data Management</td>
</tr>
<tr>
<td>High Salinity Wastewater Treatment</td>
<td>Residual Waste Management &amp; Reuse</td>
<td>Residual Micro-Pollutant Enhancement</td>
<td>Continued, Automated Operations 24h/7days</td>
<td>Stakeholder Engagement and Communications</td>
</tr>
<tr>
<td>“Zero Liquid Discharge System (ZLD)”</td>
<td>Inorganic Fraction</td>
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**Project Description**

Solvent recovery plant for the separation and recycle of waste solvents and stripping of solvents from raw waters, pretreatment for Wet Oxidation processes. This plant is composed by a vertical thin film evaporator heated by steam. The Thin film evaporator is used as distillation column reboiler making the process almost unaffected by the scaling problems that typically reduce the performance of the traditional heat transfer equipments, specially for plants treating wastes. The alimentation is fed to the thin film evaporator in the liquid phase; the high heat transfer rate warranted the thin film evaporator allows the evaporation of the lighter components that feed the distillation column while the heaviest components (normally the cause of the scaling issues) leave the TFE from the bottom. The vapors are rooted to the distillation column where the separation of the valuable fracient is completed. The Very low residence time of the product inside the TFE reduce dramatically the risk of thermal degradations or side recation that could cause scaling (for example, polymerization).

**Capacity:** 1 m³/h  
**Material of construction (wetted parts):** AISI 316  
**Heating media:** Steam  
**Operating pressure:** FV = atm  
**Service:** Solvent Separation/ Stripping, Multipurpose
KEY REFERENCES - DESIGN & BUILD

Oil Recovery

THERMOLABILE PURIFICATION PRODUCT: Omega 3 fatty acid distillation plant based on Thin Film Evaporation technology - Germany

- Skid Mounted plant (n° 2 skids)
- Thin film evaporator as distillation column reboiler, operating at high vacuum level to avoid thermal degradation
- Caustic soda concentration from 32%wt to 50%wt.

Production capacity: 5000 ton/Y, 600 kg/h
Oil Recovery

In July 2014, 3V was awarded by Robi S.r.l. (Raccolta Oli Bruciati Industriali) for the supply of the OILY WASTEWATER RECOVERY PLANT to be installed within the frame of the complex wastewater treatment and recovery center operated by Robi S.r.l., in Treviolo (Italy). Robi S.r.l. is specialized in transport, storage and recovery of waste. The Oily Wastewater Recovery Plant is realized by means of 3V Thin Film Evaporator (TFE) technology. The oily wastewater feed, after primary filtration, are pre-heated by means of heat recovery system and routed to the Thin Film Evaporator (TFE). The TFE is a machine composed by a central rotor equipped with shafts whose main purpose is to distribute the viscous oily wastewater along the internal surface of the evaporating column, where the oil devolatilization takes place. The TFE is heated by means of diathermic oil heating system which operate around 300°C. The extracted products are evaporated water and light solvents which are condensed, cooled and disposed inside the Robi treatment center and the de-volatilized recovered oil.

The Unit has been designed in order to treat a flow rate of maximum 3500 kg/h of oily wastewater, containing at design conditions at maximum 5% of water and 2% of low-boiling solvent.
Oil & Solvent Treatment & Recovery

ITALY 2013 - SOLVENT RECOVERY
FRANCE 2007 - SOLVENT RECOVERY
SAUDI-ARABIA 2011 - OIL RECOVERY
KEY REFERENCES
DESIGN BUILD OPERATE MAINTAIN

- Wastewater Spent Caustic ZLD Treatment
- Sludge & Sewage Treatment
- Oil & Solvent Treatment
- Soil & Sediment Treatment
- Drilling Mud Treatment
- Tar & Pitch Treatment
3V Green Eagle operates the largest industrial wastewater & sludge treatment center in Italy, treating up to 400,000 tons of highly contaminated wastewater and sludge from third parties per year. The heart of the center is Wet Oxidation treatment.

In addition to the above, the center also receives approximately 4,500,000 tons of wastewater per year from the nearby 3V Chemical production plant. This makes the overall treatment capacity of the center approximately 5,000,000 tons/year.

The center is located in the north of Italy, in Grassobbio (BG). We offer wastewater treatment to all clients that are interested in an effective treatment process, especially those with types of waste with high COD values, that in most cases have limited biodegradability.

Types of waste we can treat:
Our treatment center is authorized for more than 290 CER codes, which are related to different liquid waste types, primarily wastewater and sludge. Wastewater streams from more than 300 clients are conveyed by means of tank trucks (about 10-12,000 per year) to storage tanks.

The center treats an average of 6,000-8,000 tons of COD per year.

Types of Waste We Treat:
The waste we treat comes from the following sectors:

Adhesives, Antibiotics and bactericidal, Composting, Cosmetics, Detergents, Dyes, Fine Chemicals, Food, Health Sector (Hospitals), Leather Tanning, Metals, Oil, Oil mills, Paints, Paper, Pesticides, Pharmaceuticals, Photographic Industry, Plastics, Resins, Textile, Wood

3V Green Eagle is recognized as a provider of Best Available Techniques for wastewater & sludge treatment by the European Union IPPC Commission.
THE MOST REPRESENTATIVE CER CODES OF THE TREATMENT CENTER ARE:

- **060602**: wastes from the MFSU (manufacture, formulation, supply and use) of sulphur chemicals, sulphur chemical processes and desulphurisation processes (Spent Caustic Wastewater)

- **070101**: wastes from the manufacture, formulation, supply and use (MFSU) of basic organic chemicals aqueous washing liquids and mother liquors

- **070301**: wastes from the MFSU of organic dyes and pigments aqueous washing liquids and mother liquors

- **070501**: wastes from the MFSU of pharmaceuticals aqueous washing liquids and mother liquors

- **070601**: wastes from the MFSU of fats, grease, soaps, detergents, disinfectants and cosmetics aqueous washing liquids and mother liquors

- **070701**: wastes from the MFSU of fine chemicals and chemical products not otherwise specified aqueous washing liquids and mother liquors

- **080308**: wastes from MFSU of printing inks aqueous liquid waste containing ink

- **161001**: aqueous liquid wastes destined for off-site treatment aqueous liquid wastes containing dangerous substances

- **161002**: aqueous liquid wastes destined for off-site treatment aqueous liquid wastes other than those mentioned in 16 10 01

- **190203**: wastes from physico/chemical treatments of waste (including dechromatation, decyanidation, neutralisation) premixed wastes composed only of non-hazardous wastes

- **190204**: wastes from physico/chemical treatments of waste (including dechromatation, decyanidation, neutralisation) premixed wastes composed of at least one hazardous waste

- **190603**: wastes from anaerobic treatment of waste liquor from anaerobic treatment of municipal waste

- **190703**: landfill leachate - landfill leachate other than those mentioned

- **191307**: wastes from soil and groundwater remediation aqueous liquid wastes and aqueous concentrates from groundwater remediation containing dangerous substances

- **191308**: wastes from soil and groundwater remediation aqueous liquid wastes and aqueous concentrates from groundwater remediation other than those mentioned in 19 13 07

The respective industries that generates such CER codes are: detergents, chemical, pharmaceutical, dyeing, paints and coatings, groundwater wastewater and landfill leachate. Physical-chemical treatment (D9) is always followed by biological treatment (D8). Depending on waste typology, only D8 treatment can be performed (Biological Treatment). **3V Green Eagle Treatment Center receives liquid waste from the entire Italian territory.** Most of the waste is received from North-Italy, but Central and Southern Italy still have a significant share of the total. Liquid waste is received by truck.
3V Green Eagle operates the largest industrial wastewater and sludge treatment center in Italy.

The center consists of the following:

- A TOP® - Wet Oxidation plant for wastewater treatment
- A DUAL TOP® - Wet Oxidation plant for sludge treatment
- A biological plant with improved performance that operates at a constant temperature of 25°C
- A Chemical-physical pre-treatment plant
- A stripping unit
- A storage plant
- An analysis and research laboratory

The Grassobbio treatment center has been operating since 1990.
Types of Waste We Treat:

The waste we treat comes from the following sectors:

Adhesives, Antibiotics and bactericidal, Composting, Cosmetics, Detergents, Dyes, Fine Chemicals, Food, Health Sector (Hospitals), Leather Tanning, Metals, Oil, Oil mills, Paints, Paper, Pesticides, Pharmaceuticals, Photographic Industry, Plastics, Resins, Textile, Wood

Advantages of the center:

- Large treatment capacity for wastewater, especially non-biodegradable wastewater
- High capacity of segregation and storage
- Exceptionally low levels of environmental impact
- High level of system automation with centralized control of all the various treatment phases
- High professionalism of the personnel
- 24/7 operational management of the entire center

Analysis Laboratory

There is an onsite analysis laboratory at the center which aids in optimizing the waste treatment process. It performs approximately 50,000 analyses on more than 20,000 waste samples per year. The activities conducted by the analysis laboratory consist of:

- Preliminary characterization of every new type of waste treated by the center
- Analysis of each waste type arriving at the center
- Characterization of the storage and blending tanks before the treatment
- Monitoring of treatment plants which analyze over + 5,000 samples/year
- Analysis of daily sample discharge in surface water
- Real-time analysis of important parameters
- Analysis of waste and surface discharge as stated in the Environmental Integrated Authorization of the Center
- Analysis in support of the R&D department
The system has the scope of removing solvents contained in the wastewater before sending it to the subsequent treatments of the center. Maximum feed flowrate of the plant is strictly related to relative volatility of the specific solvent, to its concentration and to the working pressure. As a rough indication, a feed of about 2,000 – 3,000 kg/h of liquid treated with a solvent content between 5,000 and 60,000 mg/l can be considered.
MORE THAN 300 CLIENTS IN WHOLE OF ITALY

10,000,000
Thermal energy (kWh/year) produced in the oxidation reactions, starting from the chemical energy on the treated waste, and recoverable energy from discharge water after internal energy reuses.

115,000
Number of trucks that discharged wastewater at the Treatment Center

0.04%
Loads rejected for non-compliance

3,239,644
Total of third party industrial wastewater in m³ treated in 2014
Treating up to 5,000,000 tons/year

Our center is authorized to treat up to 400,000 tons of highly contaminated wastewater and sludge from third parties per year. In addition, we receive approximately 4,500,000 tons of wastewater per year from the nearby 3V Chemical production plant.

Wastewater streams from more than 300 clients are conveyed by means of tank trucks to storage tanks. This waste amounts to approximately 10-12,000 tons per year.

The center treats 290 different types of waste and an average of 6,000-8,000 tons of COD per year.
**BLENDING TANK**
Different streams of wastewater are equalized & blended into the perfect mixture for Wet Oxidation treatment.

**TOP® - WET OXIDATION**
- Oxidating wastewater by a combined action of high temperature (300°C) and oxygen pressure (150 BAR)
- Transforming 100% non-biodegradable waste into highly biodegradable waste.
- Reducing C.O.D. content by 70%, remaining 30% = highly biodegradable.
- Destroying contaminants up to 99.9%.
- Total detoxification.
- Residue after wet oxidation treatment is ash/powder.

**LIQUID/SOLID SEPARATION**
Through filtration the ash/powder is separated from the wastewater.
Wastewater goes to the Biological Plant.

**DUAL TOP® - WET OXIDATION**
- Oxidating wastewater & sludge by a combined action of high temperature (250°C) and oxygen pressure (50 BAR)
- Reducing C.O.D. content by 70%, remaining 30% = highly biodegradable
- Destroying contaminants up to 99.9%
- Total detoxification
- Residue after wet oxidation treatment is ash/powder.

**BIOLOGICAL PLANT**
Biological tower system with improved performance.
Constant temperature of 35°C.
Wastewater now has become highly biodegradable.
Bacteria eats up the remaining organic content.

**TOP® FILLER**
Ash/powder becomes TOP® Filler, a secondary raw material that can be used to build roads.
FROM CHEMISTRY TO ENVIRONMENT

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