Founded in 1905, Tsukishima kikai has over more than a century developed extensive expertise in diverse technology fields, ranging from waterworks, sewage treatment facilities and incinerators to industrial waste treatment, filtration, separation and other technologies. We are committed to contributing to the further development of industry and society through our continuous efforts in these fields. Now in our second century, we have taken up the challenge of entering new technological fields with high growth potential, including vacuum and biomass technologies. By adhering to the principle of “Selection and Concentration”, we aim to be a highly profitable and competitive company that keeps a sharp eye on the present, while actively pursuing new technological advancements at the frontier of innovation.

To protect our precious planet and contribute the development of industry for society

“To protect our precious planet and contribute the development of industry for society” TSK Group has been fully committed to achieve these two major objectives. In more than 100 years since founding, TSK has built and stored up TSK’s Total Technology in areas of equipment design, manufacturing, and major integrated plant. TSKE, joined TSK Group in 2005, has expanded its business and became one of the greatest engineering companies in environmental-related technology field since its foundation in the year 1958.

In the new century, TSK Group extends and develops engineering technology on a larger scale for the benefit of “people”, “society” and the “planet” from both economical and environmental viewpoints, while continuing to create new value with our products and services.
Installation Record of TSK & TSKE’s Products in Petrochemical Market

Facilities

Type of Facilities
A Distillation / Evaporation
B Crystallization / Purification
C Filtration
D Centrifuge / Decantation
E Drying
F Powder Mixer

Process Supply
1 Para-Xylene
2 Bisphenol-A
3 Para-dichlorobenzenes (PDCB)
4 Ammonium Sulfide

Environmental Facilities

Type of Facilities
A Waste Liquid Thermal Oxidizer
B Waste Gas Thermal Oxidizer
C Wastes Liquid & Gas Thermal Oxidizer with HCl Recovery Unit
D Waste Sludge Incinerator
E Catalytic Wet Oxidation System
Evaporation is very simple operation for concentrating the liquid. However, in the design of evaporator, not only theoretic but also experiential approach is required. Especially, energy saving becomes an urgent issue recently both for environmental and economic reasons, and the economical design such as multi-effect system and MVR (Mechanical Vapor Recompression) system is demanded in the current market.

We hope our longtime experience will help customers.

Falling Film Evaporator

Falling Film Evaporator has a vertical heater and vapor separator. The liquid is fed to the top of the evaporator and liquid flows down as a film. Since the holding time is very short in Falling Film Evaporator, it is suitable for heat sensitive materials.

Features
- Applicable for heat sensitive materials
- Compact footprint

Crystallizer

We have developed a unique crystallization technology and provided various kinds of crystallizer: Single Impeller type, Forced Circulation type, Element Cooling type, Oslo type, Double Propeller type (DP type), Scraped Surface type etc. We can design and provide the most suitable crystallizing method and facility in accordance with the specified requirements of customer.

DP Crystallizer

DP Crystallizer is an advanced model of conventional single-impeller-typed crystallizer and has been one of the most successful products for more than 40 years. Well-considered design realizes large-volume circulation inside the vessel at low impeller speed. We offer DP Crystallizer as the best solution to customer’s needs of big and uniform crystal product.

Features
- Big and uniform crystal product
- Long-term operation and easy maintenance
- Manufacturable for large size unit (max: 144 m³)

Scraped Surface Crystallizer

Scraped Surface Crystallizer is a particular model of indirect cooling crystallizer. Since cooling surface is constantly scraped by metal or plastic blades, it keeps high and stable heat transfer modulus for a long time.

Features
- Efficient productivity
- Stable and long-term operation

Evaporation

In general, customers prefer pure product with higher added-value. Today, product purity of 99.9% is very common, and sometimes more than 99.99% is required in the market. Though distillation is widely applied in many industrial fields to remove impurities, it has big disadvantages in both investment cost and energy consumption. It is the same in multi-stage recrystallization.

To overcome these disadvantages, we developed Process as one of solutions for 99.99% grade of product purity.

4C Process

4C Process (Counter Current Cooling Crystallization and Purification Process) is an innovative purification system, which combines Scraped Surface Crystallizer and Purification Column, without solid-liquid separation operation. Crystal formed by Scraped Surface Crystallizer is fed to Purification Column, and the impurities are washed out by utilizing melting liquid of crystal and the perspiration effect of crystal.

Features
- High purity of product: 99.99% might be possible
- High recovery ratio of raw materials
- Low energy consumption

PDCB (Para-dichlorobenzene) Production Plant

PDCB (Para-dichlorobenzene), well known as main material of mothball, is the raw material for PPS (Polyphenylene Sulfide), an engineering plastic which excels at heat resistance, chemical resistance, mechanical strength, and electrical properties. Since application of PPS is rapidly growing in electrical and electronic parts, electrical home appliance parts, and automobile parts, the demand for PDCB was expanded growing accordingly.

4C Process is apply to produce purity 99.99% of PDCB.

PDCB Production block flow

In the production block flow, the reaction is the main process where PDCB is formed by the reaction of benzene and HCl. The reaction process is followed by purification, where the product is separated from impurities. Finally, the purified PDCB is collected, and the waste gas is treated.
Dehydration is one of our core technologies. For many years, we have supplied various kinds of filter and centrifuge for wide range of applications. We are not a mere supplier of filter/centrifuge, but an all-rounder in dehydration technology. We can provide one-stop service and the optimum solution to meet the customers’ requirement of dehydration.

**Horizontal Belt Filter**

Horizontal Belt Filter is a sophisticated model of vacuum filter with efficient cake washing function, which performs 3 in 1 operation of filtration, reslurry and secondary filtration. Horizontal Belt filter enables economic process with the minimum amount of cake washing liquid. Another outstanding feature of Horizontal Belt Filter is the fractional collection of filtrate. Horizontal Belt Filter is also applicable for filtrate liquid recovery and extraction operation.

**Features**
- Efficient cake washing
- Saving cake washing liquid
- Applicable for extraction operation

**Dewaxing Filter**

This rotary vacuum filter is mainly applied for the MEK (methyl ethyl ketone) method dewaxing process in lubricant oil plant. Over 60 units have been installed to Japan, Korea, China, Singapore, Iran, and Russia.

**Features**
- Top supplier in Japan and the largest in the world
- Manufacturable for large size unit (max filtration area: dia 3,350mm x L 9,450mm)

**TSK-Bird Screen Bowl Decanter**

TSK-Bird Screen Bowl Decanter combines solid bowl decanter with a final dewatering screen section to produce minimum moisture. Complete seal type is available for harmful materials.

**Features**
- Lower moisture content of solids
- Wide range of application

**Ammonium Sulfate Recovery Plant**

Ammonium sulfate recovery from waste sulfuric acid is our strongest field. Please look at the process block flow below, and you can find our core technologies there: crystallization, dehydration, drying, waste liquid incineration, desulfurization etc. We are one of the few engineering companies that can design and provide the total optimized plant of ammonium sulfate recovery.

**TSK-Escher Wyss Push Type Centrifuge**

Compared with other centrifuges such as conical type, retention time of solids is much longer (10-20sec), power consumption is lower, and cake washing is much better. We have supplied more than 1,200 units of TSK-Escher Wyss Push Type Centrifuge with more than 300 applications of material.

**Features**
- Low residual liquid
- Low power consumption
- Good cake washing
Drying technology, one of our core technologies, is the most well-known activity of us in the world. Our long experience covers various kinds of application: dewatered cake, slurry, sludge, and powder. Particularly, we offer excellent performance and many advantages on continuous and indirect heating type of dryers such as Steam Tube Dryer (TSK-STD) and Inclined Disc Dryer (TSK-IDD).

Steam Tube Dryer (TSK-STD)

Steam Tube Dryer (TSK-STD) is an indirect heating rotary dryer with more than 500 units of sales and 70% of market share worldwide. The heat transfer area per unit volume is the largest of all the rotary dryers presently available. Gas treatment system would be minimized because of small exhaust gas from TSK-STD. We are the top supplier of dryer in the field of terephthalic acid. In addition, TSK-STD can be applied in the such as coal moisture control process.

**Features**
- Compact but large capacity
- Small amount of exhaust gas
- Easy operation and maintenance

Inclined Disc Dryer (TSK-IDD)

Inclined Disc Dryer (TSK-IDD) is an indirect heating dryer with special designed discs. Since the motion of cut-off inclined discs prevents the material from sticking the surface of discs, shaft, and casing, high evaporation performance is kept for long days. TSK-IDD can be applied to sticky and high moisture materials like municipal sludge.

**Features**
- Suitable for drying of high moisture and high viscosity materials
- Small amount of exhaust gas
- Easy operation and maintenance

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**Features**
- Suitable for drying of high moisture and high viscosity materials
- Small amount of exhaust gas
- Easy operation and maintenance

Pure Terephthalic Acid (PTA) Production Scheme

TSK’s Product Range in PTA Plant

**Features**
- Suitable for drying of high moisture and high viscosity materials
- Small amount of exhaust gas
- Easy operation and maintenance

Inclined Disc Dryer (TSK-IDD)

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**Features**
- Suitable for drying of high moisture and high viscosity materials
- Small amount of exhaust gas
- Easy operation and maintenance

Hopper Dryer

Hopper Dryer holds long retention time, and it is suitable for drying until falling rate zone. We can design, provide, and obtain mass flow and homogeneous product quality. Absence of internal moving parts makes perfect discharge possible and maintenance easy.

**Features**
- Homogeneous product quality
- Easy switching of product grade
- Easy maintenance

Poly Oxymethylene (POM) Production Process Scheme

**Methanol**
- Formaldehyde synthesis
- Formalin concentration
- Trioxane synthesis
- Trioxane concentration
- Trioxane refiner
- Polymer reaction
- Grind
- Deactivation
- Dehydration drying
- Stabilization pelletizing
- TEA

**Ethylene Glycol**
- Catalyst

**Solvent**
- TEA

**Product**
- TEA: Tri-Ethanol Amine
Desulfurization systems can be divided into a dry system, a semi-dry system, and a wet system. Tsukishima Kikai has technologies, such as the pre-coated bag system for dry desulfurization, the alkali mist system for semi-dry desulfurization, and the gypsum recovery system, MgSO₄ purge system, Na₂SO₄ recovery system, Na₂SO₃ recovery system, and seawater system for wet desulfurization.

Seawater Process

TSK proposes Seawater FGD System in partnership with Fujikasui Engineering Co., Ltd.

Features
- Low construction cost
- Low running cost
- No absorbent chemical is required
- Trouble-free simple construction
- Stable and easy operation
- No fouling trouble
- Good Experience: 19 installation records in the world System flow

Na₂SO₃ Recovery Process

Features
- High SO₂ absorbing efficiency
- Pure Na₂SO₃ crystals are produced
- Low energy consumption due to MVR System employed for crystallizer
- Scaling free crystallizer

MgSO₄ Purge Process

Features
- High SO₂ absorbing efficiency
- High operating flexibility
- Low pressure drop at absorber
- Scaling free system
- Low investment cost
- Minimized quantity of waste water discharge

Tsukishima Kikai has been addressing the treatment of SO₂ in flue gas since 1960s. The company has delivered desulfurization units, tailored to meet individual needs of the Customers at diverse plants, for desulfurization treatment of flue gas such as dry type, semi-dry type and through process technologies of lime-gypsum method, sodium sulfate method, magnesium hydroxide method and sodium sulfate recovery method.

The company has been concentrating on various flue gas treatments for a broad range of customers in dealing with flue gas from heavy oil and cai-combustion boilers, glass-melting furnaces, rotary kilns, sulfuric acid plants and smelting furnaces.
Environmental Facilities

Submerged Combustion System

Submerged Combustion System is to treat by incineration various liquid waste discharged from various production processes of petrochemical, fine chemical, pharmaceutical, agrochemical, pulp and other industries without secondary pollution.

Features

- TSKE is enjoying top share in the field.
- Can be reduce the risk of public nuisance.
- The complete decomposition of the organic substances in the liquid waste is achieved regardless of kind or character of the liquid waste.
- The system can avoid secondary pollution.

What kinds of liquid wastes can be treated?
The Sub-Com can treat a wide variety of liquid wastes including organics and inorganic compounds from as follows:

(1) Petrochemical production plants: Acrylic Acid, Acrylic acid Esters, Propylene Oxide and Sulphone Monomer, Acrylic Nitrate, Waste liquid from caprolactam plant.
(2) Liquid Waste from Agrochemical and Pharmaceutical intermediates.
(3) Liquid Waste from pulp, dye and soda industries, and waste liquids resulting from photographic, etc. can also be treated.

How to control the operation of the submerged incineration system?

(1) Local control panels
(2) Local touch control panels
(3) DCS (Distributed Control System) All system including safe operation.

The Sub-Com can treat a wide variety of liquid wastes including organics and inorganic compounds from as follows:(1) Petrochemical production plants: Acrylic Acid, Acrylic acid Esters, Propylene Oxide and Sulphone Monomer, Acrylic Nitrate, Waste liquid from caprolactam plant.
(2) Liquid Waste from Agrochemical and Pharmaceutical intermediates.
(3) Liquid Waste from pulp, dye and soda industries, and waste liquids resulting from photographic, etc. can also be treated.

Chlorine Drying Process

High-performance packing, SPIRAX (TELLERETTE®), allows you to use only one tower to dry the chlorine extracted from electrolysis facilities.

Hydrochloric Acid Recovery and Concentration System

Technical know-how is required for handling high acid concentration. Our extractive distillation method was developed to process exhaust gas containing hydrochloric gas by recovering and concentrating hydrochloric acid of any concentration (from low to 100%) for individual requirements.

Hydrochloric acid can be recovered from waste hydrochloric acid or organochloride by installing an incinerator at the preliminary stage to produce hydrochloric gas by combustion and by incinerating unwanted organic matters.

Features

- The system can be combined with the combustion of VCM, EDC, or waste plastic.
- Waste heat boiler can be used for steam recovery or electric power generation.
- Recovers and purifies hydrochloric acid of any concentration (including hydrochloric gas).
Since local exhaust ventilation contains various components with often low concentration, the combustion method is advantageous.

**Features**

a) Thermal Oxidizer

- Applies to gas containing much dust or waste gas with high heating value.
- Converts the least amount of fuel among the three methods.
- Uses a flame, so reaction temperature is mild and the risk is small.

b) Catalytic Combustion System

- Applies to gas containing much dust or waste gas with high heating value.

**Catalytic Wet Air Oxidation System**

Detoxifying COD components in Effluent water by catalyst with high-efficiency liquid phase oxidation reaction.

WAO is a high-efficiency liquid-phase oxidation reaction process developed under technical license from Nippon Shokubai Co., Ltd. High running costs were a drawback for conventional combustion treatment. With WAO, a solid catalyst performs efficient liquid-phase oxidation and decomposition of COD components in effluent water, at high temperature and high pressure. WAO not only exhibits high performance for persistent cases that are difficult with biological treatment, but is effective for treating effluent water with much inorganic COD components as well.

**WAO Process**

WAO process decomposes organic compounds into air, oxidant, CO₂ and water in the catalytic reaction chamber.

Nitrogen compounds are decomposed into N₂, generating virtually no NOx.

Sulfuric compounds are detoxified after sulfur components are changed into Na₂SO₄ through decomposition with a catalyst and addition of NaOH solution.

**Operative Conditions**

- **Low / pressure method**

  - ~0.9MPaG (9kg f/cm²)
  - ~165°C (Pressure Vessels of Grades 1 and 2)

- **High / pressure method**

  - ~7.3MPaG (73kg f/cm²)
  - ~265°C (High Pressure Gas Safety Law. Pressure Vessel of Grade 1)

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Environmental Facilities

**Vent Gas Incinerator System**

**Bio-Treatment System**

- **Features**

  - Accurate distribution of granules by multi-stage reaction zones, and control over small-size granules.
  - Significantly higher performance than the products made by other companies
  - Realizing high reduction rate in the high load condition

  - Application: Organic compound concentration
  - Targets: 0.5 to 5 wt.

- **Features of Aero Salom**

  - Rotating aeration tube installed at the bottom of the reactor continuously supplies air to the filler inside the reactor
  - Periodic air shearing effect on the whole surface of the filler prevents clogging the filler

- **Features of Anaerobic treatment with small methane fermenter granules**

  - Conventional granules (produced by other company) 4mm to 6mm

  - TSK Granules by High-Efficiency UAAS 4mm

- **Aerobic using fixed biofilm**

  - Reduction of organic materials as pre-treatment of a activated sludge unit in the next stage
  - Direct discharge to sewage treatment plant without settling tanks at the next stage
  - Effluent is processed in settling tanks, coagulation-flocculation tank or filters before discharge into rivers and seas at the next stage

  - Efficacy: Reduction of organic concentration
  - Target: 0.1 to 0.5wt%
Environmental Facilities

SPIRAX Tower Packing

Meeting diverse service conditions as a pioneer of tower packing.

We have been developing and producing “TELLERETTE ®”, a plastic filler, for more than 40 years as a pioneer of resin fillers in Japan. “TELLERETTE ®” has been employed in absorption towers in many industrial fields and built expertise in water treatment field; especially, we have a lot of achievements mainly of deaeration and deodorization towers for facilities typified by water supply and sewage systems.

Features

- Large usable area with no dead surface area (surface not exposed to liquids)
- Low pressure loss with line structure that allows high void rate and decreasing tower diameter
- High liquid dispersion efficiency with curved line structure and many contact points in packing layers
- Lightweight, strong chemical and mechanical properties with synthetic resin
- Ease of filling and extraction using lightweight material
- Ease of removing adhesion

Property Table of SPIRAX

<table>
<thead>
<tr>
<th>Type</th>
<th>S-S</th>
<th>S-O</th>
<th>S</th>
<th>S-II</th>
<th>M</th>
<th>L</th>
<th>L-II</th>
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<td>FE</td>
<td>PP</td>
<td>FE</td>
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<td>Outside diameter (mm)</td>
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<td>51</td>
<td>59</td>
<td>73</td>
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<td>Height (mm)</td>
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<td>19</td>
<td>19</td>
<td>27.5</td>
<td>37</td>
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<td>Nominal fillings (mm)</td>
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<tr>
<td>Total surface dimension (m²/m³)</td>
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<td>185</td>
<td>180</td>
<td>150</td>
<td>127</td>
<td>94</td>
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<td>Full (kg/m³)</td>
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<td>90</td>
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<td>Weight (kg/m³)</td>
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<td>60</td>
<td>77</td>
<td>73</td>
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</table>

Each type of SPIRAX can be made out of PFA, TTFE or PVDF.

Rasching Super-Ring™ Fourth Generation Column Packing (Random Packing)

The evolution to the line structure from the surface structure made it possible to achieve “greater KGa” and “smaller delta P”, simultaneously.

The rasching ring, the root of all sort of fillers, is a surface structured filler invented more than 100 years ago. Rasching Co., the same company which developed the raschihing ring, developed the most evolutional fourth generation metal line structure filler, “Rasching Super-Ring (RSR)”. Our company formed a business alliance with Rasching Co. in 1997 and has been providing their products mainly in the Japanese market since then.

Features

- Smooth gas flow and reduced pressure loss with alternating wave structure
- Liquid film flow with entangled packing, similar to our latest model SPIRAX, resulting in large material transfer (Same effect is confirmed with our product, TELLERETTE®)
- Flooding at joints prevented with “Semi Structured Packing”
- Support ring do not have to be completely removed when remodeling shelf block towers (However, when remodeling to standard packing, supporting need to be completely removed up to the outer/circumference edge)
- Reduced number of redistributors with homogeneous liquid distribution
- Cost saving with high-speed machines

Rasching Super-Ring

<table>
<thead>
<tr>
<th>Model number</th>
<th>Weight (kg/m³)</th>
<th>Bulk Quantity (number/m³)</th>
<th>Surface Area (m²/m³)</th>
<th>Void (%)</th>
<th>Size (Diameter) [mm]</th>
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</table>

ROMBOPAK Structured Packing for Distillation and Absorption

The structured packing with the different structure and a unique performance.

KUHNI-ROMBOPAK is a wildly used systematic packing which is characterized by its special structure. Unlike other systematic column packings its surface is subdivided into a multitude of small lamellas, generating conditions close to the ideal for both the liquid and vapor flow. As a result, performance of ROMBOPAK is excellent with respect to efficiency, pressure drop and capacity.

Features

- The circular packing elements consist of parallel layers of grids having small inclined lamellas. The overall surface is therefore subdivided into a large number of surface elements. This structure as well as the special assembly of the packing elements leads to the following characteristic features:
- Large specific packing surface
- Streamlined form
- Unique distribution effect for the liquid
- Complete and equal wetting of the packing surface combined with a continuous renewal of the liquid film
- Good distribution of the vapour flow

Packing types

- Rombopak® 4M and 54M high capacity packing
  - 150m³/m³
  - up to 2.2 NTSM
  - very high capacity
- Rombopak® 6M and 56M standard packing
  - 230m³/m³
  - up to 4.0 NTSM
  - wide range of application
- Rombopak® 9M and 59M high efficiency packing
  - 350m³/m³
  - up to 5.5 NTSM

- Rombopak® 12M ultra high efficiency packing
  - 450m³/m³
  - up to 7.5 NTSM