The New Era of Waterworks in the 21st Century

Chatan Purification Plant

Advanced Water Treatment Facilities

Water Softening Facility

Okinawa Prefectural Enterprise Bureau

Water Production by the Advanced System of the New Century

Chatan Purification Plant

The Chatan Purification Plant, located close to the seashore of Chatan Town on Okinawa Island, is the largest purification plant in Okinawa with a daily production capacity of 214,300m³.

The plant is equipped with an advanced water treatment facilities, and designated as the core plant of the West Coast Water Resources Development Project and the Seawater Desalination Project, both of which are promoted by the Okinawa Prefectural Enterprise Bureau.

The facility takes surface waters from the Fukuji Dam, Yamashiro Dam, Kurashiki Dam, Hija River, Nagata River and Tengan River, as well as ground water from Kadena Wells, which are scattered in and around the U.S. Kadena Air Base.

In the Chatan Plant, facilities are connected to the central monitoring room by fiber-optic cables, which enable advanced computer control of water operation and management.

Water produced at the plant is supplied to the south of Okinawa City, the southwestern part of the center of the island, and some districts of Naha City.

Address: 1-27 Miyagi, Chatan Town, Nakagami-gun, Okinawa

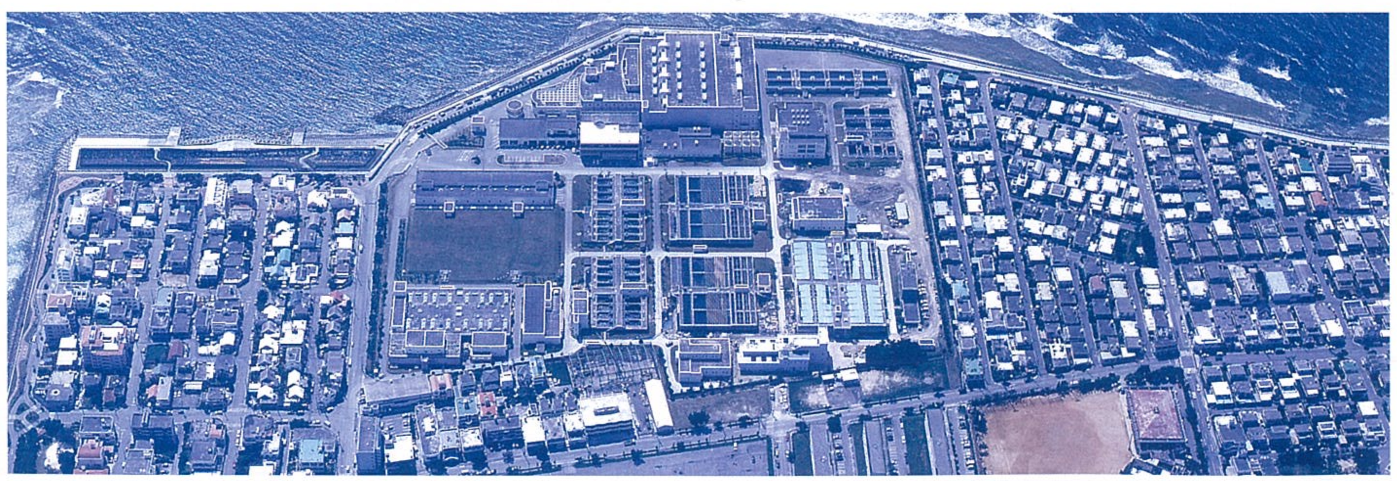
Area: 100,254m²

Water Resource: the Fukuji Dam, Yamashiro Dam, Kurashiki Dam, Hija River, Nagata River, Tengan River, and Kadena Wells

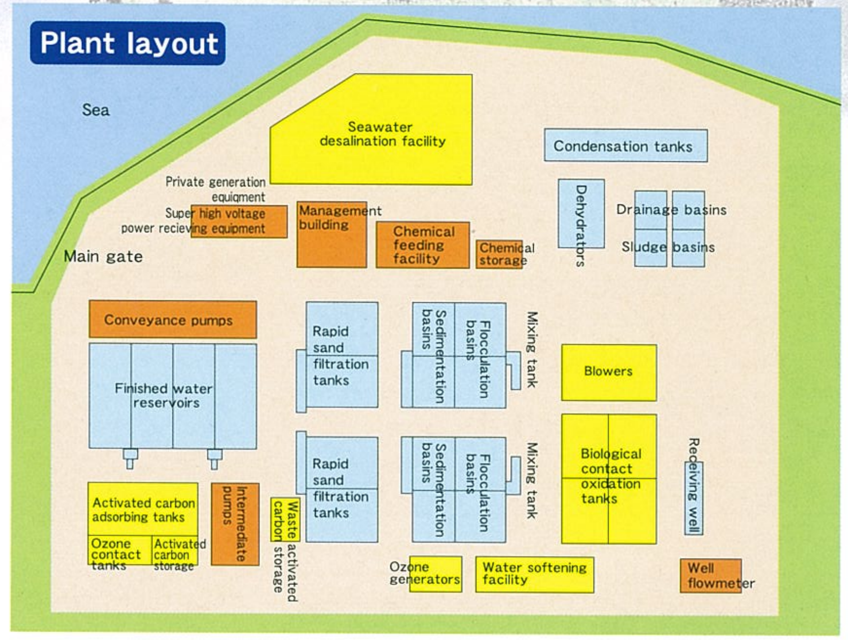
Production capacity: 214,300m³ /day (incl. groundwater)

Mainly supplies water to: Chatan Town, Okinawa City, Kitanakagusuku Village, Ginowan City, Nakagusuku Village, Urasoe City, and Naha City

Total construction cost: Conventional water treatment facility: approx. 24.7 billion yen
Advanced water treatment facilities : approx. 22.2 billion yen



Advanced Water Treatment System



The quality of water in the Hija, Nagata, and Tengan Rivers in the middle of the island, from which the plant takes water, suffered deterioration annually, and it became increasingly difficult to treat the water satisfactorily using the conventional treatment process. Therefore, the Enterprise Bureau installed an advanced water treatment plant tentatively to conduct a series of experiments and examinations. The Bureau consequently reached the decision to introduce an advanced treatment system equipped with three processes: biological, ozonation and activated carbon treatments in addition to the conventional treatment process.

First, the biological treatment applies the self-cleansing mechanism of rivers to the water treatment process, in which aerobic bacteria consume organic matter contained in raw water, achieving a certain purification level. Next, in the ozone treatment, ozone, a gas produced by oxygen reaction in the atmosphere, decomposes organic matter with its deodorizing, bleaching and disinfecting ability due to its strong oxidization power, which is second only to fluorine.

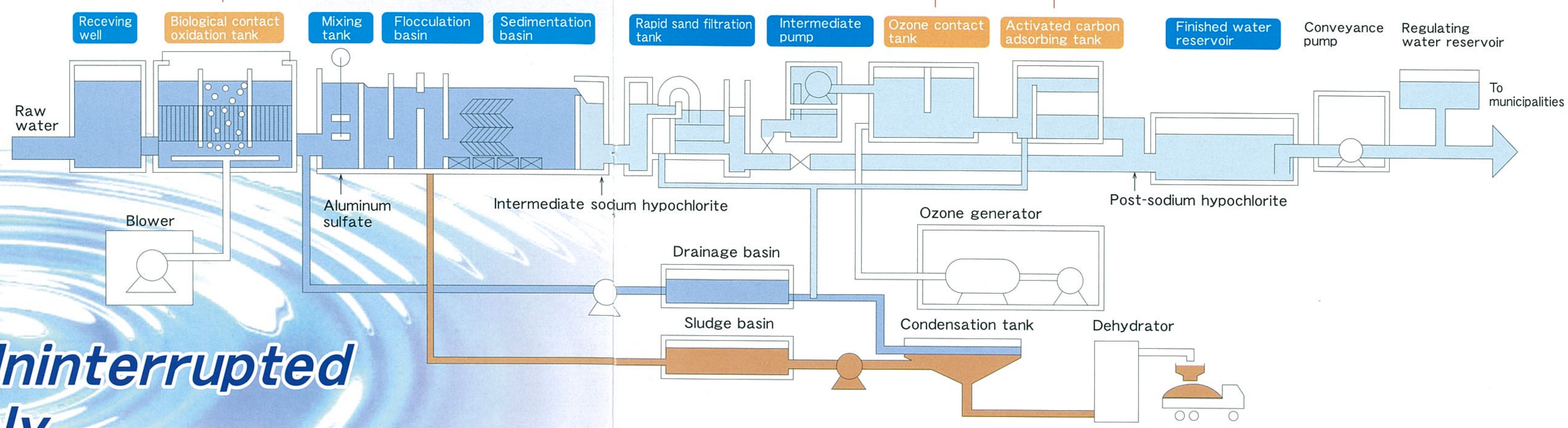
In the final process, granular activated carbon adsorbs odors and organic carbons present, with its high adsorbent quality provided by countless inner micro pores. The activated carbon is a form of carbon produced by baking coal or similar carbon-based matter at a very high temperature.

The combination of the above treatments added to the conventional water treatment system has realized the conversion of highly polluted water into safe, good-tasting water.

History of Chatan Purification Plant

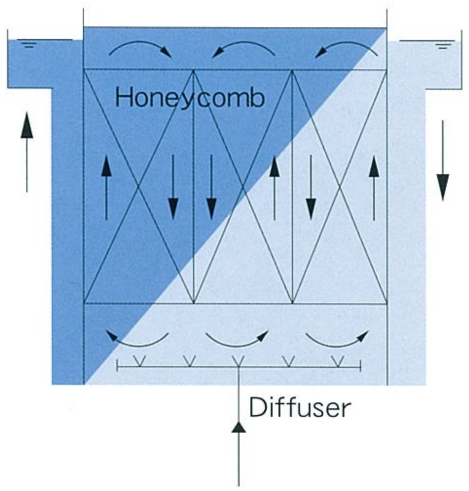
Year	History
1982	Initiated construction.
1984	Set up a water quality examination committee to conduct research into the future projection of water quality on the experimental plant using the advanced weter treatment process.
1985	Conducted comparative research into the three biological treatment methods and confirmed the positive effect of the honeycomb aeration method.
1986	Completed the 1st stage of construction.
July 1987	Took in water to the conventional weter treatment facility.
1986 to1987	Confirmed the trihalomethane reducing effect of the ozone and activated treatments.
1987	Developed the basic plan for an advanced weter treatment facilities.
1988	Obtained approval from the former Ministry of Welfare (current Ministry of Health, Labor and Welfare) for the introduction of an advanced weter treatment facilities.
September 1988	Initiated the construction of a biological treatment facility.
1990	Initiated the construction of ozone and activated carbon treatment facilities.
June 1990	Completed the biological treatment facility and put operation.
1991	Partially completed the ozone and activated carbon treatment facilities.
June 1992	Started partial operation at the advanced weter treatment facility.
1994	Completed the advanced weter treatment facilities.
June 1995	Completed the redevelopment of Kurashiki Dam, and started to intake. Started partial operation at the Seawater Desalination Facility.
1997	Completed the Seawater Desalination Facility.
June 2003	Started operation at the Water Softening Facility.

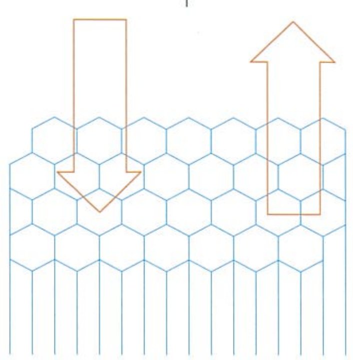
Flow of advanced water treatment process



For Safe, Uninterrupted Water Supply

Biological contact oxidation tank



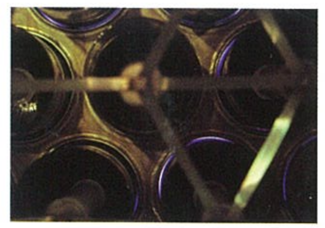


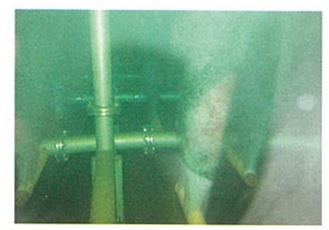
Architecture of biological contact membrane

The process applies the self-cleansing mechanism of rivers to the water treatment process, in which aerobic microbes(bacteria) oxidize and decompose matter in water, resulting in the reduction of ammonium nitrogen, algae, musty odor, iron, manganese, anionic surface active agent, etc.
Circulation of water with aeration to activate microbes, to and fro the biological membranes attached to contact material in a honeycomb-like architecture, provides a high water treatment effect equal to the natural self-cleansing mechanism of rivers.

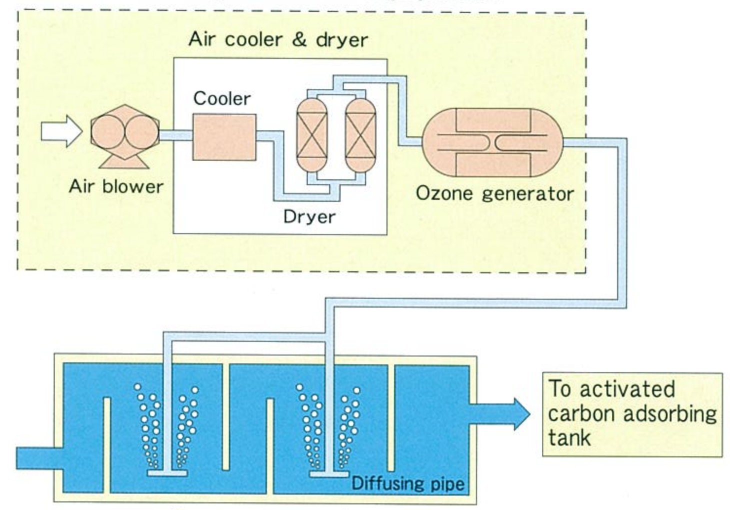
Ozone contact tank

Ozone has strong oxidization power, which is capable of disinfecting, deodorizing, bleaching, and oxidizing iron and manganese, as well as decomposing, cyanide, phenols, anionic surface active agent, and humic materials that generate trihalomethanes.
The system sprays ozone-rich air from diffusing pipes, producing highly effective contact with filtered water.





Ozone production equipment

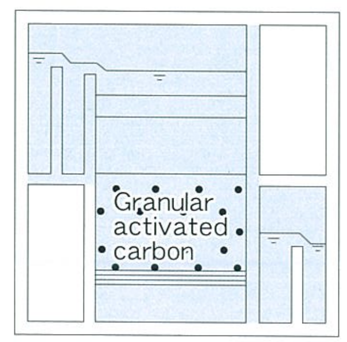


Ozone contact tank

Production of ozone

For the production of ozone, first dust and particles in the atmosphere are removed. Then, after cooling and drying the air, oxygen is converted into ozone by applying a high voltage (approx. 6,000 to 7,000V) and high frequency (1,000Hz).

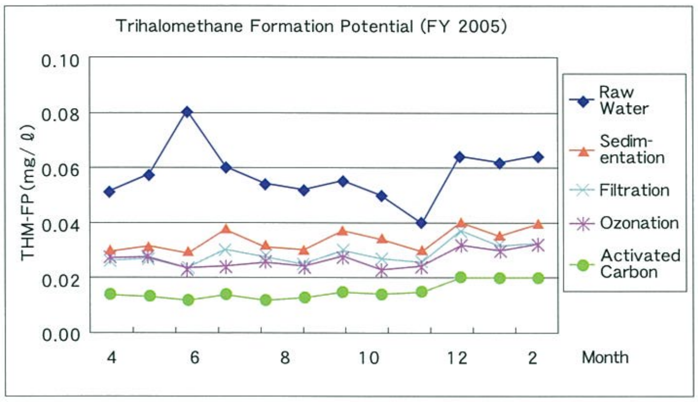
Activated carbon adsorbing tank

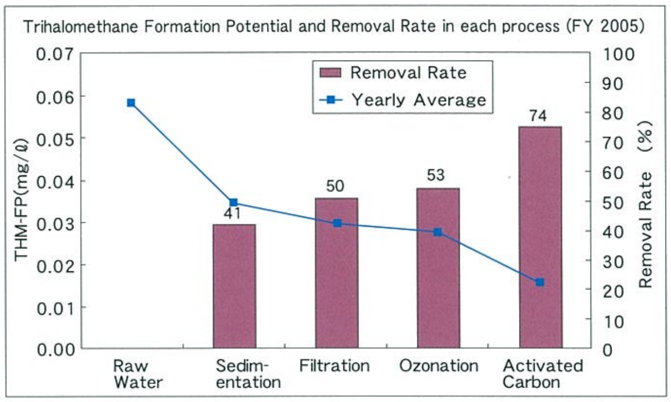


After the ozone treatment, activated carbon with its high adsorbing capacity adsorbs and removes unsavory odors/tastes/color, and anionic surface active agent, phenols, and organic matter generated during the ozone treatment.
The dissolved oxygen level stays high after the ozone treatment, allowing the microbes developing on the large surface area of granular activated carbon to provide a further decomposing function (biological activated carbon treatment).

Effects of advanced water treatment system

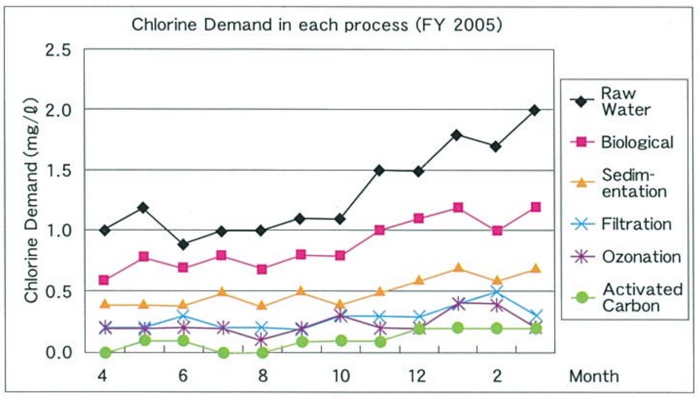
The advanced water treatment facilities at the Chatan Purification Plant comprise three processes: biological treatment, ozonation and granular activated carbon treatment. The biological treatment reduces ammonium nitrogen and levels chlorine demand, which changes significantly from hour to hour. The ozonation decomposes organic matter in the raw water, and the granular activated carbon treatment removes trihalomethane precursors and odor-causing compounds with its high adsorption power and biological activated carbon function. The facilities have been in operation since June 1992, and has shown satisfactory treatment results in regard to trihalomethane and chlorine demand reduction as follows (data as of 2005):

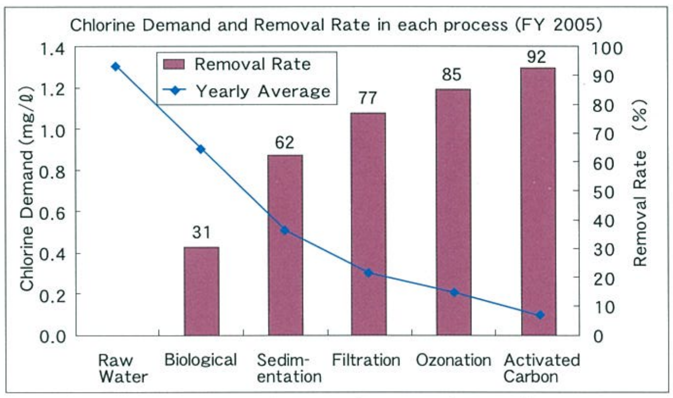




It used to be once difficult to control the amount of trihalomethane at the end of the water supply network below the water quality criteria (0.1 mg/ℓ) in summer, due to the seasonal rise in water temperature. The introduction of advanced water treatment has realized a substantial reduction in trihalomethane concentration.

Figure shows each process's trihalomethane formation potential and THM-FP reduction rate compared to that of raw water. The overall removal rate reaches 74 percent.





The reduction effect of the chlorine demand is particularly remarkable in the biological treatment and sedimentation process. The chlorine demand stood at 0.9 to 2.0 mg/ℓ in the raw water has dropped to 0.1mg/ℓ in the activated carbon treated water.

The chlorine demands are lowered in all processes and over 90 percent of chlorine demand is removed at the stage of activated carbon treatment. Consequently realizes a substantial reduction in the amount of chlorine dosage.

What is trihalomethane?

The purpose of disinfecting drinking water is to remove pathogenic bacteria that cause disease in man. Though disinfection by chlorine has many more advantages than other disinfecting methods, it has a drawback. That is the formation of trihalomethanes (THMs) caused by the reaction of chlorine and organic matter. Their water quality criterion is established along with other tap water standards to ensure safe drinking water. At the Chatan Purification Plant, the advanced water treatment facilities have been introduced to reduce the concentration of THM.

What is the chlorine demand?

Chlorination is used in water treatment to ensure satisfactory disinfection of potable water supplies. Raw water contains a trace of organic matter. When chlorine is added to the raw water, the chlorine reacts with this matter. In the water treatment at purification plants, sufficient chlorine must be added to completely oxidize such organic matter. A certain amount of chlorine must also remain in the water after the completion of oxidization, so that the effects of the chlorine treatment remain stable. This is called residual chlorine, and the chlorine demand refers to the amount of chlorine required to infuse (in mg/ℓ), until residual chlorine is secured after a certain period of contact with treated water.

Facility Outline

Water Treatment Facilities

Facility	Specification
Receiving well	RC construction: 8.1m×19.6m×11.3m ×1 well(W×L×D)
Biological contact oxidation tank	RC construction: 10.2m×10.2m×5.0m×24 tanks(alternative aeration honeycomb tube type)
Mixing tank	RC construction: 4.1m×4.1m×4.1m ×2 tanks
Flocculation basin	RC construction: 15.2m×27.5m×4.7m ×4 basins(vertical circum flow type)
Sedimentation basin	RC construction: 26.5m×27.5m×3.5m ×4 basins(horizontal inclined plate type)
Rapid sand filtration tank	RC construction: 5.0m×10.1m ×32 tanks (50.5m² each)
Ozone contact tank	RC construction: 8.80m×3.85m×5.0m ×double ×4 tanks
Activated carbon adsorbing tank	RC construction: 5.0m×10.8m ×16 tanks Layer of granular activated carbon: 1.5m thick
Finished water reservoir	RC construction: 21.6m×52.6m×2.5m ×4 tanks Total capacity: 11,000m³
Treated water machinery	＊Mixing tank stirrer: Flat turbine type ＊Sedimentation basin sweeper: Underwater towed clarifier
Chemical feeding facilities	＊Aluminum sulfate feeding facilities 390L/hr ×3 injectors 0.6 m³×2 pressure tanks 90m³×3 storage tanks ＊Sodium hypochlorite feeding facilities 90L/hr ×3 intermediate-injectors 150L/hr ×3 post-injectors 0.6 m³ ×2 pressure tanks 12m³×2 storage tanks
Ozone generator	8.1kg-O_3/hr ×4 water-cooling multi-cylinder silent dischrging machines
Intermediate pump equipment	Horizontal two-way inhalation swirling pumps 33.7m³/min×10m×75kW ×5 pumps
Conveyance pump equipment	Horizontal two-way inhalation swirling pumps For Yamazato areas: 15.07m³/min×99m×390kW×2, and 15.07m³/min×99m×350kW×3 pumps For Nana areas: 22.13m³/min×100m×570kW×4, and 22.13m³/min×100m×520kW×1 pumps

Power Facilities

Facility	Specification
Super high voltage power receiving and transforming equipment	＊Especially high gas insulation locking system (GIS) ＊Main transformers (infusion auto-cooling type) 4,000KVA×1, and 6,000KVA×1 transformers
Private generation equipment	＊Engine: Simple open cycle monopole gas turbine ＊2,500KVA×2 generators

Wastewater Treatment Facilities

Facility	Specification
Drainage basin	RC construction: 15.1m×30.2m×5.8m ×2 basins
Sludge basin	RC construction: 11.8m×15.1m×5.8m×2 basins
Condensation tank	RC construction: 16.9m×16.9m×4.0m×4 basins
Dehydrator	Chemical-free long-term horizontal pressure extractor: 710m² filter cloths×4 Dehydrators 12 m³×4 cake storage hoppers

Water softening project

Circumstances

The average water hardness of the Chatan Purification Plant is higher than those of other Okinawa Prefectual Enterprise Bureau plants by 100mg/L. This is caused by the Kadena wells' high calcium water hardness resulting from the geological structure of limestone. Water hardness can not be removed by conventional water treatment. And one of the palatable water criterions is the water with hardness between 10 to 100mg/L. So the Water Softening Facility was introduced to the Chatan Purification Plant to treat and soften the Kadena Wells' raw water in FY 2001.

Coping with hard water

OPEB made various investigation to rectify hard water in public water supplies from FY 1985 to FY 1988.

①FY 1985 Investigation of measures to cope with hard water ·········Basic investigation of feasibility of leveling hardness by mixing soft and hard water (both raw and finished water) and softening water technology

②FY 1986 Experiment of removing hardness from ground water of Kadena wells ··· Feasibility investigation of softening by chemicals which gives most satisfactory results in Europe and America

③FY 1987 Second experiment of removing hardness from ground water of Kadena wells ··· Experiment of ion-exchange method and reverse osmosis

④FY 1988 Third experiment of removing hardness from ground water of Kadena wells··· Experiment of ①acceleration of chemical softening
②seawater desalination by ion-exchange
③water softening by pellet softener

As a result of experiment pellet softening method is adopted for the reason that
①high rate of hardness removal
②fewer scaling problems compared with chemical softening method
③better water quality (speedup of filtration)
④easy to maintain
⑤no need to treat wastewater
⑥pellets can be used in various ways

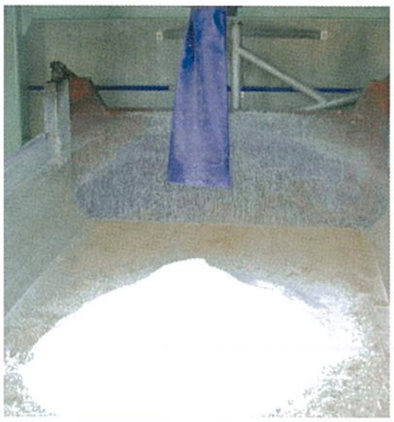
⑤December 2001 Started designing the Water Softening Facility and completed the design inMarch, 2002

⑥March 2002 Started constructing the Water Softening Facility

⑦June 2003 Started operation of the Water Softening Facility

Pellet reactor

Injection of seeding grains



Release of pellets

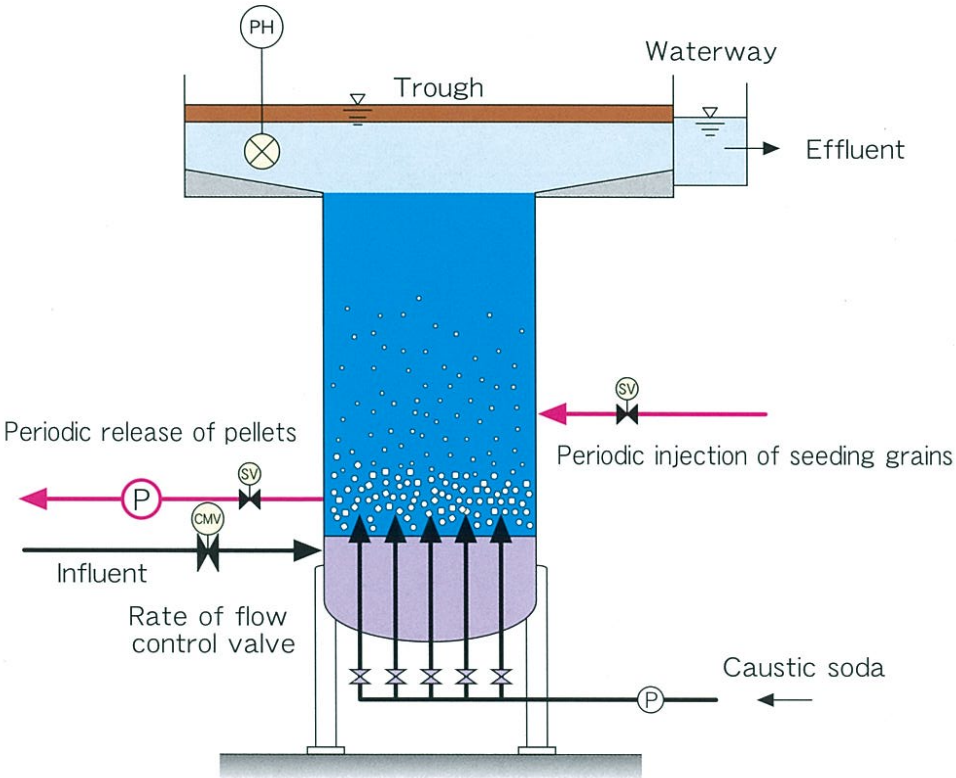
Basic principles of pellet softeners

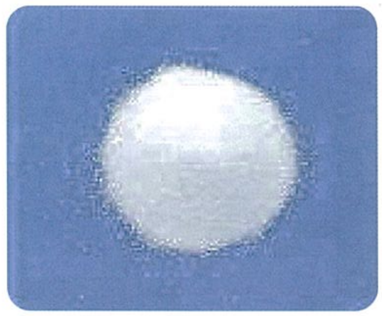
Pellet reactors are equipments that efficiently remove water hardness by rapid crystallization of calcium carbonate which takes place in fluidized bed of grains. If the pH is increased to 8 or higher by the addition of alkaline substance, generation of insoluble calcium carbonate occurs. Calcium carbonate tends to adhere and once its scale is formed on the inside of the reactor, it is difficult to remove it. To prevent the formation of scale, seed grains are injected into the water and crystal grows on the seed grains. The grains move freely in the upward flow of the water so that cementing of grains is prevented. During operation the grains in the reactor increase to 1mm to 2mm in diameter. Because large grains have small reactive surface, they should be removed regularly and replaced by smaller-diameter seeding grains.

$$Ca(HCO_3)_2 + NaOH \rightarrow CaCO_3 \downarrow + NaHCO_3 + H_2O$$

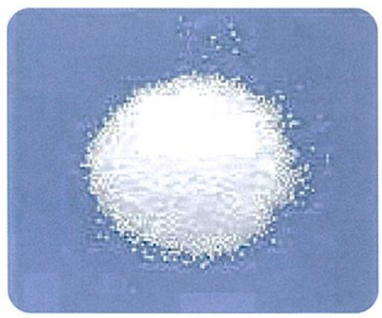
Calcium hydrogen carbonate + Caustic soda → Calcium carbonate + Sodium hydrogen carbonate + Water

Schematic diagram of pellet reactor





Seeding grains



Pellets

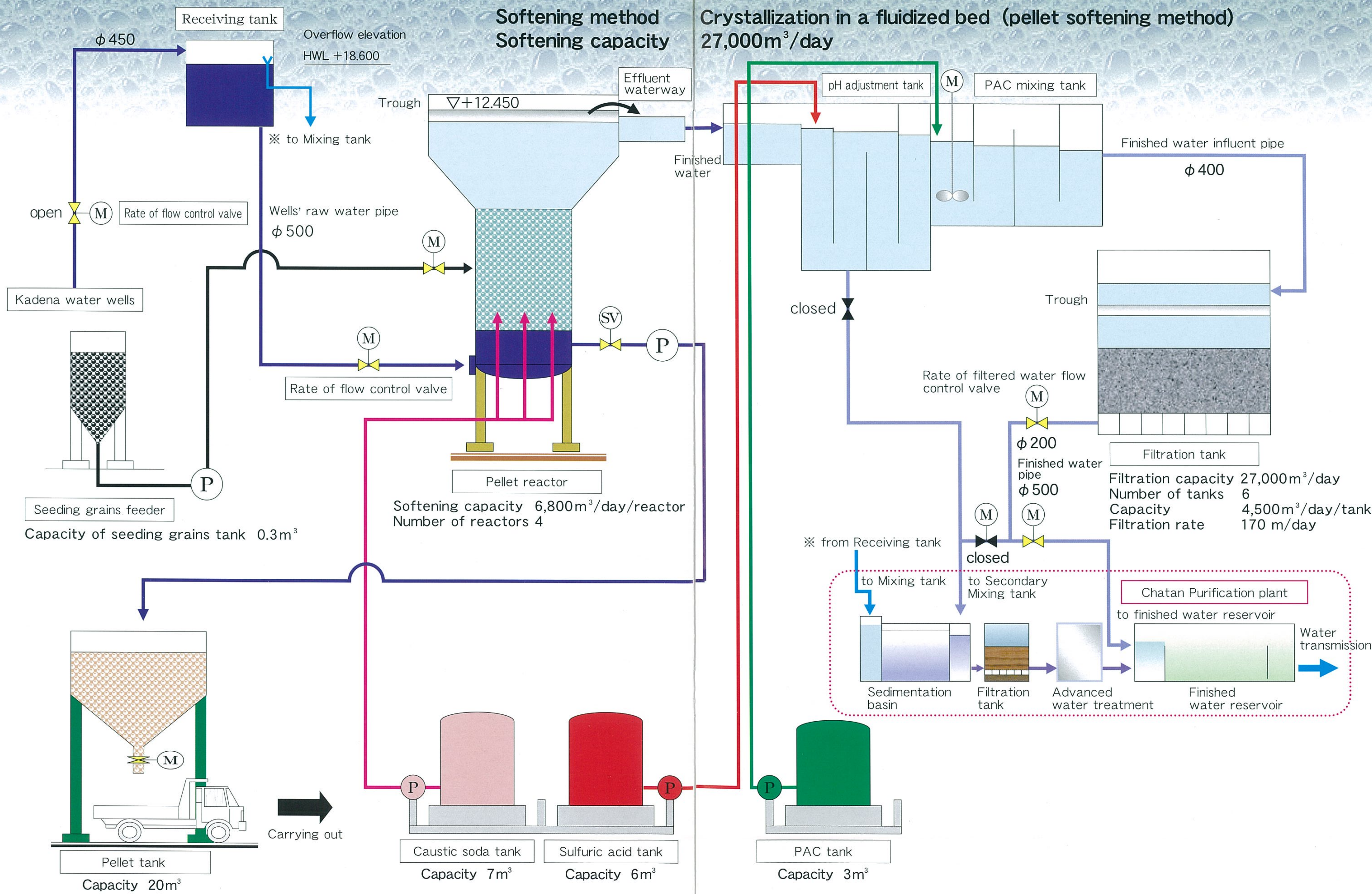
Pellet reactor
Softener capacity : 6,800m³/day/reactor
Number of reactors : 4

Capacity	6,800m³/day/reactor	
Velocity	100m/hour	
Diameter	φ 1,900mm	
Height	Reactor	4.0m
	Total height	7.0m

Total hardness	Kadena wells :	
	Raw water	330mg/l
	Finished water	80mg/l
PH	During reaction	8.1～8.6
	After adjusted	7.1～7.4

Schematic flow diagram of the water softening facility

Softening method　Crystallization in a fluidized bed (pellet softening method)
Softening capacity　27,000 m^3/day



Outline

Name	Water Softening Facility
Softener capacity	27,000m^3/day
Water resource	Kadena wells

Water quality

Item	Kadena wells' raw water	Kadena wells' finished water	Water quality criterion
Total hardness (mg/l)	330 (average 1995~2006)	80	300 no higher than

Equipment

Item	Specification	quantity
Pellet reactor	method : crystallizaiton in fluidized bed (pellet softening method) diameter : φ1.9 m height : about 7 m material : SUS304 capacity : 6,800m^3/day/reactor	4
Seeding grains feeder	type : hopper with conical lower part dimensions : φ500mm×H2,600mm material : SUS304	1
Pellet tank	type : lower part discharge hopper dimensions : φ2,900mm×H4,500mm material : SUS304	1
Filtration tank	type : gravity rapid filtration method : microfloc process filtration rate : 170m/day	6
Caustic soda tank	capacity : 7m^3 material : FRP	1
Sulfuric acid tank	capacity : 6m^3 material : FRP	1
PAC tank	capacity : 3m^3 material : FRP	1

Structure

facility	Structure and specification
Pellet reactor bldg.	RC structure, area of total floors : 1,050m^2
Receiving tank	RC structure, capacity : 253m^3
Filtration wash-water tank	RC structure, capacity : 218m^3
Wash-water pumping well	RC structure, capacity : 70m^3

editor and publisher

Okinawa Prefectural Enterprise Bureau

Chatan Purification Administration Office

1-27 Miyagi, Chatan town, Okinawa 904-0113 tel. 098-936-7796

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