

Meeting Your Compressed Air Treatment Needs

How to Select the Right Equipment for Your Application



Six Levels of Compressed Air Treatment

Dryer Selection

Filter Selection

Selecting System Accessories

Glossary and Reference Data

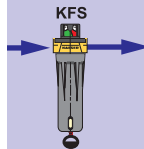
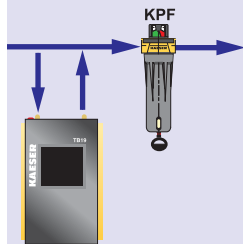
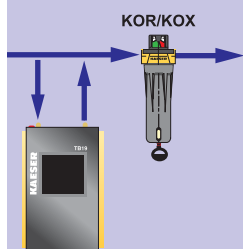
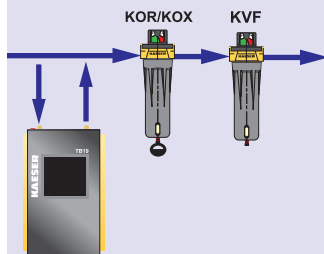
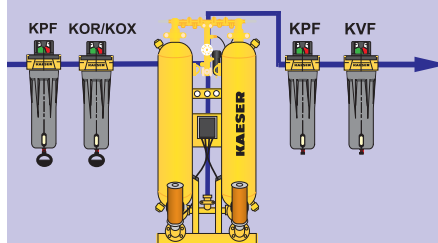
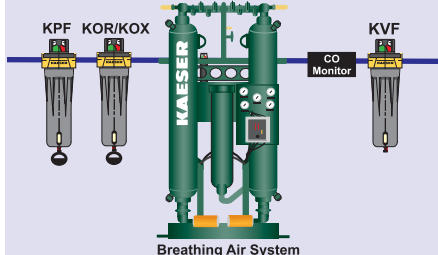
Meeting Your Compressed Air Treatment Needs

Why do we need compressed air treatment? Because ambient air contains contaminants that are drawn into the compressor. These contaminants are compressed and intensified and find their way into the compressed air system. Contaminants are also introduced into the compressed air stream by the compressor, receiver tank, piping, and other installed components. There are three different forms in which contaminants exist:

- **Solids** - dirt, dust, pipe scale, compressor wear particle
- **Liquids/Aerosols** - oil and water
- **Gases/Vapor** - water, oil (hydro-carbons), carbon monoxide, chemical pollutants

Compressed air applications range from shop air to breathing air—with a wide range of applications in between. Because the application determines the type of air treatment required, the first step in meeting your air treatment needs is to look closely at your application and the air quality it requires. Also, remember that individual applications requiring high air quality should not dictate the design of your overall system. Instead, point-of-use care can often be a cost-effective solution.

Six Levels of Compressed Air Treatment

	<p>Level 1 Filtered Centrifugal Separator removes all solids three microns and larger. Removes liquids: 99% of water droplets, 40% of oil aerosols. ISO 8573.1 Quality Class: 3.—5 <i>Application: Primary stage for all compressed air treatment levels</i></p>
	<p>Level 2 Refrigerated Compressed Air Dryer produces pressure dew points as low as 35°F. Air Line Filter removes 70% of oil aerosols and all solid particles one micron and larger. ISO 8573.1 Quality Class: 2.4.4 <i>Applications: Air Tools, Sand Blasting</i></p>
	<p>Level 3 Refrigerated Compressed Air Dryer produces pressure dew points as low as 35°F. Oil Removal Filter removes 99.999% of oil aerosols and all solid particles .025 microns and larger. ISO 8573.1 Quality Class: 1.4.2 <i>Applications: Instrument Air, Paint Spraying, Powder Coating</i></p>
	<p>Level 4 Refrigerated Compressed Air Dryer produces pressure dew points as low as 35°F. Oil Removal Filter removes 99.999% of oil aerosols and all solid particles .025 microns and larger. Oil Vapor Adsorber removes oil vapor, oily smell and taste. ISO 8573.1 Quality Class: 1.4.1 <i>Applications: Food Industry, Chemical and Pharmaceutical Industry</i></p>
	<p>Level 5 Air Line Filter removes 70% of oil aerosols and all solid particles one micron and larger. Oil Removal Filter removes 99.999% of oil aerosols and all solid particles .025 microns and larger. Low Dew Point Desiccant Dryer produces pressure dew points as low as -100°F. ISO 8573.1 Quality Class: 1.1.1 <i>Applications: Breweries, Dairy Industry, Electronics Industry</i></p>
 <p style="text-align: center;">Breathing Air System</p>	<p>Level 6 Breathing Air System (Continuous or Portable) removes common harmful compressed air contaminants and will produce Grade D breathing air. ISO 8573.1 Quality Class: 1.2.1 <i>Application: Breathing Air</i></p>

Refer to ISO 8573.1 Quality Class Chart in glossary (back page).

Dryers

Don't dilute the performance of your compressed air system

Atmospheric air entering a compressor always contains water vapor, or humidity. At 75°F and 75% relative humidity, for example, 20 gallons of water will enter a typical 25 hp compressor during one day of operation. When air is compressed, this water content is concentrated. While the air naturally heats up during compression, the water remains vaporized. When, however, the compressed air travels downstream and cools, the vapor condenses into liquid droplets. This water is unacceptable for many applications and can also contaminate an entire compressed air system and lead to corrosion, air leaks, pressure drops, and scale formation.

Commonly used dryer types include: refrigerated air dryers, desiccant air dryers, deliquescent dryers, and membrane dryers.

Refrigerated Air Dryers: These are the most economical type of dryer. Warm and saturated air from the air compressor is cooled to a temperature of 35°F to 50°F. At these temperatures, the water condenses and can be mechanically separated and discharged from the system. Air, now free of liquid moisture, can be reheated and

discharged into the compressed air system. This air now has a 35°F to 50°F pressure dew point, which means the air temperature has to drop below this temperature before further condensation occurs.

Desiccant Air Dryers: These dryers are used in applications that require compressed air at dew points as low as -100°F. Through two identical drying towers, each containing a desiccant bed, air flows alternately. While one tower is on-stream drying, the other is off-stream being regenerated. Purge air is used to regenerate the desiccant.

Diameter and length of desiccant beds determine drying efficiency. Bed diameter controls air velocity through the bed. If velocity is too high, the desiccant will float or fluidize, causing desiccant degradation. Bed length determines consistency of the dew point: the bed must be long enough to ensure sufficient contact time between the wet air and the dry desiccant to reach the proper outlet dew point.



The heart of the system

The heart of any compressed air system is the air compressor itself. When selecting an air compressor, the most important factors to consider are quality and reliability. Reflected in quality and reliability are overall cost, efficiency, and easy maintenance. The most cost-effective unit is rarely the lowest priced. Components to evaluate in a compressor include:

- **Airend:** look at the package efficiency and check with the manufacturer for CAGI data sheets. Evaluate proven performance and reliability. For rotary screw compressors, the Sigma Profile developed by Kaeser Compressors can provide up to 20% savings in energy consumption.
- **Drive:** efficiency is critical. Belt drive units offer the most flexibility in pressure selection. While true direct drive units with the airend coupled directly to the motor (as opposed to gear driven units), offer maximum transmission efficiency.
- **Motors:** look for high and premium efficiency motors which meet or exceed the EPA's requirements. While ODP motors might be sufficient for some applications, TEFC motors provide excellent protection from the environment and are better suited for industrial applications.
- **Starters:** reduced voltage starters are becoming more popular even in smaller sizes down to 7.5 hp due to their "soft starting" capabilities. Look for Wye-Delta starters or variable frequency drives.
- **Controls:** system must be reliable, readable, and run the compressor efficiently.
- **Cooling System:** must be adequate to handle extreme ambient operating temperatures.
- **Interconnecting Piping:** look for rigid piping with flexible connections to eliminate leaks.

Refrigerated Air Dryer Operation

Warm compressed air (1) entering the dryer is initially cooled in the air-to-air heat exchanger (2) by the cold compressed air leaving the dryer. This allows for greater efficiency by reducing the heat load on the refrigeration system. The air is cooled to the designed dew point temperature in the lower part of the heat exchanger (2) by a refrigerant circuit with a thermal mass (3). The condensate formed by the cooling action is separated from the compressed air by a multi-stage, stainless steel, maintenance-free separating system (4). The automatic condensate drain (4) reliably drains the

water without wasting valuable compressed air. The dried air leaving the dryer is reheated in the upper part of the heat exchanger (2) before exiting the outlet (5). Reheating the compressed air eliminates pipe sweating downstream.



Filters

Protect System Components and Maintain Product Quality

Compressed air systems contain contaminants that increase operating costs by:

- contaminating product
- damaging air-operated equipment
- clogging air lines and restricting air flow to equipment

The right filter depends on the needs of your particular application. The most basic filtration is provided by a **Filtered Centrifugal Separator**, which combines separation and filtration in one housing. Using principles of centrifugal force and impaction, a well-designed filter's first stage is 99% efficient in removing particles 10 microns and larger. The second stage is a replaceable filter sleeve which removes solids and liquids down to three microns through coalescence.

Air Line Filters should be designed to remove liquid aerosols, rust, scale, dirt, and other solid particles one micron and larger. These operate with two stages: a first stage of coarse media collects larger particles and a second stage of finer media separates dirt, water, and oil-aerosols. Particulate filters are very versatile and have application in systems using both oil-lubricated and non-lubricated compressors. In oil-lubricated systems, a good filter can also be used as an oil removal filter with over 70% efficiency or used in combination with other filters to remove particulates. In non-lubricated systems, they are used upstream and downstream of the desiccant dryers to remove desiccant dust/fines.

Coalescing Oil Removal Filters remove oil aerosols that contaminate end products, ruin paint jobs, and gum up air tools. In a typical 100 psig air system, 72% by weight of oil aerosols are

less than five microns and 50% are below one micron. These droplets will pass right through a mechanical separator and cannot be completely removed by an air line filter. A good coalescing oil removal filter has a liquid oil removal rate of over 99.999%. Air is directed through a maze of submicronic glass fibers where the oil aerosols are coalesced into larger droplets and continuously removed.

Oil Vapor Adsorbers are final stage filters which adsorb oil vapor by passing the compressed air through two levels of activated carbon. They eliminate smell and taste by removing oil vapors as well as any other gaseous hydrocarbons normally adsorbed by activated carbon. They should be installed after the oil removal filter because liquid oil aerosols will prematurely saturate the activated carbon and significantly reduce adsorptive capacity.

High Temperature Afterfilters are primarily designed as afterfilters for heated desiccant dryers, but can be used wherever large amounts of solid particles are present in dry air. They can hold a large number of desiccant fines without plugging. Large dust particles settle in the bottom of the filter housing due to reduced velocity and a sharp shift in direction. Medium-size particles are collected on the surface of a layer of glass fiber cloth, while fines one micron and smaller are collected on beds of in-depth fiber glass media.

Moisture Separators are important for removing bulk liquids and are typically installed after the aftercooler.



What Size Contaminants are Found in a Compressed Air System?

If .01 micron is this big



Then .1 micron is this big



And 1 micron could not fit on this page!

Measured in microns (μm)

1 millionth of a meter or 0.000039 inches

Solid particles: .5 to 5 μm

Water aerosols: 1 to 2 μm

Oil and oil aerosols: .01 to 5 μm

Visible to eye: 50 μm

Human Hair (cross section): 40 μm

Bacteria: .3 to 4 μm

Tobacco smoke: .1 to 1 μm

Viruses: .003 to .05 μm

Built for a lifetime.™



Extra-fine filter shown



Filtered Centrifugal Separator

The Kaeser Filtered Centrifugal Separator uses centrifugal separation and mechanical filtration to remove bulk liquids from a compressed air system.



Particulate Filter

Available in models from 20 scfm to 16,000 scfm, the Kaeser Particulate Filter removes liquid aerosols, rust, scale, dirt, and other solid particles one micron and larger.



Coalescing Oil Removal Filter

Used within its rated design conditions, the Kaeser Oil Removal Filter eliminates the oil aerosols contained in a compressed air system. Its unique, continuously stabilized filter medium plus outer foam sleeve ensure 99.999+% efficiency for the life of the cartridge.



Oil Removal Filter

Oil Removal Filters are final stage filters which adsorb oil vapor (gaseous oil) present in compressed air. Kaeser Oil Removal Extra Fine Filters pass the compressed air through two levels of activated charcoal to remove gaseous oil contamination and any offensive oily smell.

General Compressed Air Treatment Sizing Considerations

Component	Sizing Considerations				
	Compressed Air Pressure	Compressed Air Temperature	Compressed Air Relative Humidity	Ambient Temperature	Air Quality Level Required at Inlet
Filters	Capacity increases as pressure increases	Capacity decreases as temperature increases	Usually sized for worst case 100% relative humidity	Capacity does not change	Based on micron ratings. Some filters should have pre-filters.
Aftercoolers				Sizing is based on approach temperature ⁽²⁾	No prefiltration is necessary
Refrigerated Dryers				Capacity decreases as temperature increases	Some need a pre-filter (check with manufacturer)
Heatless Desiccant Dryers		Capacity does not change. Dewpoint is better at lower temperatures	Usually sized for worst case 100% relative humidity	Capacity does not change	Oil aerosol-free air
Heat Reactivated Desiccant Dryers		Capacity decreases as temperature increases	Capacity does not change		
Breathing Air Systems		Capacity does not change. Dewpoint is better at lower temperatures ⁽¹⁾	Capacity does not change	Capacity does not change	Check with manufacturer
Membrane Dryers		Capacity decreases as temperature increases	Capacity decreases as humidity increases		Oil aerosol-free air
Deliquescent Dryers					No prefiltration is necessary

(1) Within reasonable temperature ranges - check with manufacturer

(2) Difference between ambient and compressed air temperature

Built for a lifetime.™



Heatless Desiccant Dryer



Membrane Dryer

Desiccant air dryers continued

Channeling, when an air stream finds a path through the bed and follows the path instead of flowing evenly throughout the bed, is often a problem with desiccant dryers. Channeling can be avoided by using stainless steel diffusers in the inlet and outlet of the desiccant towers and controlling air velocity through the desiccant bed.

Desiccant dryers are either cold regenerative or heat regenerative. In cold regenerative dryers, 15% of dried compressed air is diverted from the air outlet and is used to purge the wet desiccant bed. In heat regenerative desiccant dryers, purge air is heated to 300 to 400°F and directed through one of the desiccant towers. Depending on the heated dryer type (internally heated, externally heated, blower purge, etc.), only a small percentage of 1 to 7% of purge air is diverted from the dried air stream. Valuable purge air is saved,

reducing operating costs up to 40% in applications over 500 cfm.

Deliquescent Dryers: These dryers rely on chemical action and produce a dew point of only 20°F below inlet temperatures. Their condensate is very corrosive. Maintenance requirements are relatively high.

Membrane Dryers: These utilize the newest technology for compressed air drying. The process is quite simple: compressed air passes through a bundle of hollow membrane fibers and the water vapor permeates the membrane walls. The dried air continues down the tubes and into the downstream air system. The main drawback is the relatively large amount of costly and unrecoverable compressed air (sweep air) lost through the membrane walls along with the water vapor.

Cold Regenerative Desiccant Dryer

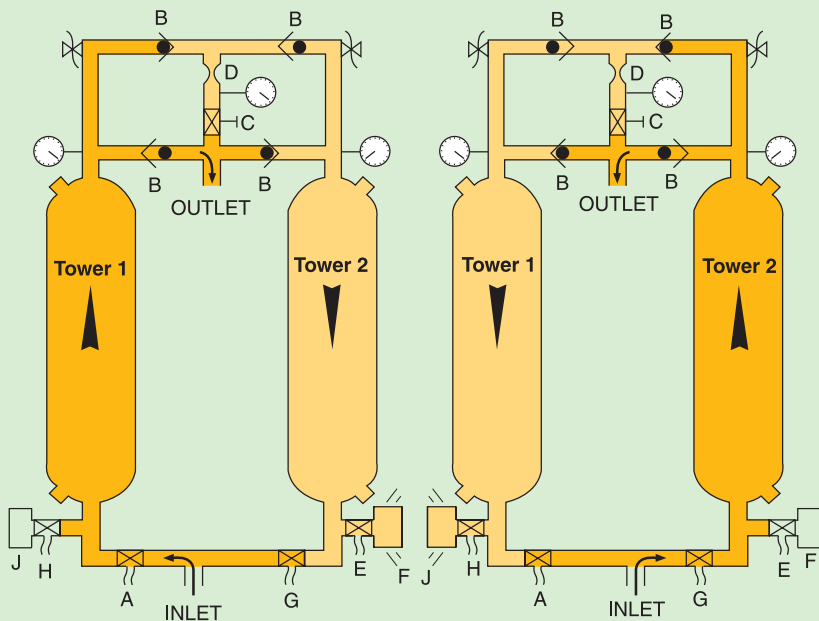


Figure 1

Figure 2

The main air stream enters drying Tower 1 (Figure 1) through inlet switching valve (A), is dried by the adsorptive capacity of the desiccant, and is directed by a system of check valves (B) to the air outlet. A portion of the dried air is throttled to near atmospheric pressure by means of an adjustable purge rate valve (C) and purge orifice (D). This extremely dry, low pressure purge air flows through and regenerates the desiccant in Tower 2. The moisture laden purge air is exhausted through purge/repressurization valve (E) and exhaust muffler (F) to the atmosphere. After a predetermined period of time, the automatic solid state timer closes purge/repressurization valve (E), which allows Tower 2 to repressurize slowly. Inlet switching valve (A) then closes and inlet switching valve (G) and purge/repressurization valve (H) open.

The main air flow is now dried by Tower 2 (Figure 2) while Tower 1 is being reactivated. Purge flow is exhausted through purge/repressurization valve (H) and muffler (J).

Drain Traps and Aftercoolers

Drain Traps reduce plant operating costs, lower maintenance, and prevent air lines from flooding. They eliminate bleeding expensive compressed air through pet-cocks or manually draining compressed air lines and equipment. A ball valve should precede all drain traps to facilitate routine maintenance without interruption.

Demand-Operated Drain Traps

automatically discharge moisture and oil-containing condensate from the system. Drain traps should discharge only liquids, not costly compressed air, and do not require a maintenance-intensive strainer upstream of the condensate inlet. They can be used on air receivers, inter- and after-coolers, refrigerated dryers, separators, filters, and header piping.

Timed Electric Traps are not a practical option. Not only do they release costly compressed air in addition to condensate, but the discharge process can create a stable emulsion which cannot be easily separated and increases disposal costs.

Aftercoolers are necessary to reduce discharge temperatures to 110°F and below. They can be either air-cooled or water-cooled.

Air Suitable for Breathing

If the application calls for purified air for face masks, hoods, helmets, and other supplied-air breathing apparatus, you need a breathing air system. These are complete unitized, purification systems designed to remove excessive moisture, solid particulates (dust and dirt), oil and oil vapor, carbon monoxide, and other hydrocarbon vapors commonly found in

ordinary compressed air. Air flows through a breathing air system, including a number of filter-purifying stages, and various contaminants are removed at each stage until final “Grade D” level air is produced, which is air suitable for breathing under OSHA standards.

Air Main Charging Valve

To ensure consistent air quality and to protect filters from over pressurization and damage during start-up, it is a good idea to isolate the air supply components. An Air Main Charging Valve is an economical and relatively simple way to limit pressure to the appropriate levels, and prevent overloading the system with air flow. A ball or butterfly type valve installed before the main air receiver, is connected to and controlled by a pressure switch. When the compressor is started — for the first time or after a weekend shutdown — the pressure switch engages the valve as soon as the maximum pressure is reached. The valve prevents high velocity flows of air from traveling downstream and dumping residual condensate back into the system.

Air Quality Monitor

With more and more companies operating under ISO certification, many plant engineers need a method of ensuring process air quality. Air Quality Monitors use capacitance hygrometers and photometers to accurately and reliably analyze compressed air contamination, pressure dewpoint, temperature and reliably analyze a given point in the system. The real-time monitoring and variable alarm set points provide broad sensing capabilities. Most units can be easily customized for different systems or applications.



Automatic Magnetic Drain Trap



Eco-Drain Series Drain Traps



Breathing Air System



Air Quality Monitor

Rules of Thumb

- Most water-cooled aftercoolers will require about 3 gpm per 100 cfm of compressed air at discharge pressures of 100 psig.
- The water vapor content at 100°F of saturated compressed air equals about two gallons per hour for each 100 cfm of compressor output.
- For every 20°F temperature drop in saturated compressed air, 50% of the water vapor condenses into liquid.
- Under average conditions, every 100 cfm of air compressed to 100 psig produces 20 gallons of condensate per day.
- Locate filters and dryers in the air line before any pressure reducing valve (highest pressure) and after air is cooled to 100°F or less (lowest temperature).
- Compressed air filters can produce air that is up to 250,000 times cleaner than the air we breathe.



Mission Statement

We strive to earn our customers' trust by supplying high quality Kaeser air compressors, related compressed air equipment and premium blower systems. Our products are designed for reliable performance, easy maintenance, and energy efficiency. Prompt and dependable customer service, quality assurance, training, and engineering support contribute to the value our customers have come to expect from Kaeser. Our employees are committed to implementing and maintaining the highest standards of quality to merit customer satisfaction. We aim for excellence in everything we do.

Our engineers continue to refine manufacturing techniques and take full advantage of the newest machining innovations. Extensive commitment to research and development keeps our products on the leading edge of technology to benefit our customers.

KAESER COMPRESSORS

Built for a lifetime.™

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Compressed Air Treatment Glossary

- **Aftercooler:** Heat exchanger for cooling air discharged from air compressors; can be either water-cooled or air-cooled.
- **Air/Oil separator:** A device in the compressor that separates oil from the air/oil mixture compressed in the aircend.
- **Breathing air systems:** Air purifying systems that produce compressed air meeting OSHA standards for Breathing Quality Compressed Air.
- **Cubic feet of air per minute (cfm):** Volume delivery rate of air flow
 - Cubic feet of air per minute, free air (cfm fad):** cfm of air delivered to some specific point and converted back to ambient (free air) conditions.
 - Actual cubic feet per minute (acfm):** Flow rate of air measured at some reference point and based on actual conditions at that reference point.
 - Inlet cubic feet per minute (icfm):** cfm flowing through the compressor inlet filter or inlet valve under rated conditions.
 - Standard cubic feet per minute (scfm):** Flow of free air measured at a reference point and converted to a standard set of reference conditions (e.g., 14.7 psia, 60°F, and 0% relative humidity).
- **Drain Traps:** Collect and discharge liquids from aftercoolers, separators, receivers, dryers, filters, and drip legs.
- **Dryers:** Remove moisture from compressed air.
 - Refrigerated dryers** cool air to remove moisture by using a refrigeration cycle.
 - Desiccant dryers** reduce dew point by flowing wet air through desiccant beads; heat reactivated desiccant dryers use heat to regenerate the desiccant bed and are more economical than cold regenerative desiccant dryers at higher cfm ratings.
 - Deliquescent dryers** reduce dew point through chemical reaction of air with desiccant tablets.
 - Membrane dryers** reduce dew point by passing compressed air through a bundle of hollow membrane fibers; water vapor and a portion of the compressed air then permeate the membrane walls to vent to atmosphere.
- **Pressure:** Force per unit area.
 - Pounds per square inch (psi):** Force per unit area exerted by compressed air.
 - Pounds per square inch absolute (psia):** Absolute pressure above zero pressure.
 - Pounds per square inch differential (psid):** Pressure difference between two points.
 - Pounds per square inch gauge (psig):** Gauge pressure, measured as the difference between absolute pressure (psia) and ambient pressure.
- **Pressure dew point:** Temperature at which water will begin to condense out of air at a given pressure. To ensure that no liquid water is present, the pressure dew point must be less than the lowest temperature to which the compressed air will be exposed.

ISO 8573.1 Quality Classes

ISO 8573.1 was developed in 1992 by ISO (International Organization for Standardization) to help plant engineers specify desired compressed air quality globally by providing "Quality Classes" for solid particulates, humidity and oil. Quality classes provide engineers with an internationally accepted unit of measure. A typical pharmaceutical plant, for example, would have a compressed air specification of ISO Quality Class 1.2.1. This is equivalent to 0.1 micron particulate filtration, -40° F (-40°C) dew point, and 0.008 ppm (0.01 mg/m³) oil filtration.

Quality Classes	SOLIDS	MOISTURE		OIL	
	Maximum particle size (microns)	Dew Point °C	Dew Point °F	Liquid and Gas mg/m ³	ppm _{w/w}
0	as specified	as specified	as specified	as specified	as specified
1	.01	-70	-94	0.01	0.008
2	1	-40	-40	0.1	0.08
3	5	-20	-4	1	0.8
4	15	3	38	5	4
5	40	7	45	>5	>4
6	—	10	50	—	—