DISSOLVED AIR FLOTATION BATCH TESTER

Model DBT6

OWNER'S MANUAL

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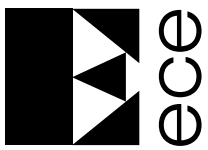

EC Engineering

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Safety precautions

Please read this manual before attempting to unpack, set up, or operate the equipment and pay attention to all the warnings, cautions and notes. Failure to do so may result in injury to the operator or damage to the equipment.

1. This equipment has been designed to operate on either a 115 V 60 Hz or a 230 V 50/60 Hz AC power supply, as specified at the time of ordering. The electrical requirements for each unit are indicated on the label above the power receptacle on the rear of the base unit. Do not attempt to use the equipment with any other power source than is indicated on this label.

2. Most of the modules making up the system have been designed to be drip and splash resistant, but they are not waterproof. Take care to avoid submerging the components or subjecting them to unnecessary amounts of water. This is particularly important in the case of the base unit, where water could enter the ventilation holes. If water does enter the base unit or recycle injection module, immediately disconnect the equipment from the power supply. Leave the equipment to drain and dry out completely, then have it checked by a qualified electrician before using again.

3. The jar support platform (illuminated diffuser) is sealed to the base unit and can accept spillage from the jars. From time to time, check that the diffuser is not cracked or damaged, and that there is no visible leakage of water through the joint between the diffuser and the base.

4. Do not hold the paddles while they are turning, or in any other way try to stop them from rotating. This could cause injury or damage the drive mechanism. Turn the motor switch off before placing the mixer module on the base or removing it.

5. Each air injection station has an on/off switch on the recycle module. Except when being used for recycle injection, these switches should always be in the “off” position. This will ensure that there are no unintended discharges of recycle water resulting from accidentally pressing a start button or some other cause.

6. The saturator vessel is charged with compressed air during normal operation. Before refilling the vessel, release the pressure by pulling the pull ring on the pressure relief valve. Do not attempt to open the vessel until all pressure has been released. The pressure relief valve has been factory set at 140 psi, and is not adjustable.

7. Do not operate the saturator with an insufficient quantity of water. Doing so could result in a violent discharge of air from the saturator vessel to the injection nozzles, and splashing of water from the jars. Before each run, check that there is an adequate volume of water in the saturator. This can be gauged by the weight of the saturator vessel, or by shaking it gently.

8. The main power supply to the unit is protected by a 2 amp fuse. Repeated failure of this fuse indicates a faulty electrical condition and the equipment should be checked by a qualified electrician. Do not replace the fuse with one of a higher rating.

Packing list

The items listed below should be included in your DBT6 shipment. Please check that all items are present and undamaged; contact ECE or your dealer if there is any problem.

MAIN CASE [33" x 16½" x 7¾", 51 lb (840 x 420 x 195 mm, 23 kg)]

- Plywood case with foam rubber padding, handle, hinges, and clasps
- Base unit
- Mixer module
- Recycle module
- White plastic background curtain
- Six sample containers (jars), with threaded adapters

DAF CASE [29" x 16¼" x 11", 52 lb (735 x 410 x 280 mm, 23 kg)]

- Plywood case with handle, hinges, and clasps
- Stainless steel pressure vessel with hatch, air inlet connection, water outlet connection, pressure gauge, and pressure relief valve
- Air compressor (if supplied)[1], with air hose and end fittings
- Baffle / dosing module
- Recycle tubing with end fittings
- Plastic bag containing six sets of jar fittings (stopcock, cap, tubing adapter, and tubing), and speed presets adjustment tool
- Plastic bag containing spare jar fittings
- Six each: 50 mL beaker; 5 mL syringe; 1 mL syringe
- Screwdriver and bits
- Power cord
- Dust cover
- Owner's manual

[1] An air compressor is not usually supplied with exported systems to be used with 230 volt electrical power - see Section 2.8.

SERIAL NUMBER

Each DBT6 system has a unique serial number. This can be found on the back of the base unit, immediately above the power cord receptacle.

1. Introduction

The so-called jar test is an old water treatment test procedure, first introduced in the 1930s. It has remained essentially unchanged since then, although there have been various refinements such as increased mixing speeds and the use of square jars instead of cylindrical beakers.

As basic as the jar test may be, it remains one of the best methods of assessing and optimizing the various processes and options available for treatment of potable and other types of water. Properly done, it can provide a great deal of information during all phases of a treatment system's development - initial process screening and development, equipment sizing, operational optimization, and evaluation of potential alternative treatment methodologies. All this can be achieved at relatively little cost, and without the need for a great deal of high-tech knowledge and expertise.

However, unlike most analytical procedures used in the water supply industry, there is absolutely no standardization of jar testing procedures and the results are almost always open to different interpretations and conclusions. Therefore, a great deal of thought and care, as well as more than a little experience, is essential if the jar test procedure is to achieve its full potential.

The dissolved air flotation (DAF) process is relatively new to the water supply industry, particularly in North America and certain other parts of the world, as is equipment for batch testing. One or two designs have been made available to the industry from time to time, but these have been somewhat expensive, awkward to use, bulky, and often difficult to obtain. The DBT6 system offers several significant improvements in ease of operation, portability, low cost, and relevance to real-world conditions.

It is not the intent of this manual to discuss in detail all the various planning, objectives, calculations, procedures, and other considerations that are involved in conducting a jar test; this information is available from many different sources. Rather, the intent is to describe the aspects of the procedures that are specific to DAF jar testing and the DBT6.

The illustration shows the main features of the DBT6 system.

The base unit (**1**) contains the jar support base, drive motor, DC power supply, fluorescent lamp, and system controls.

The solid black vertical surface (**2**) behind the jars provides a uniform background for observation of samples. A white plastic curtain sheet is supplied for insertion behind the jars for work with color removal and similar processes.

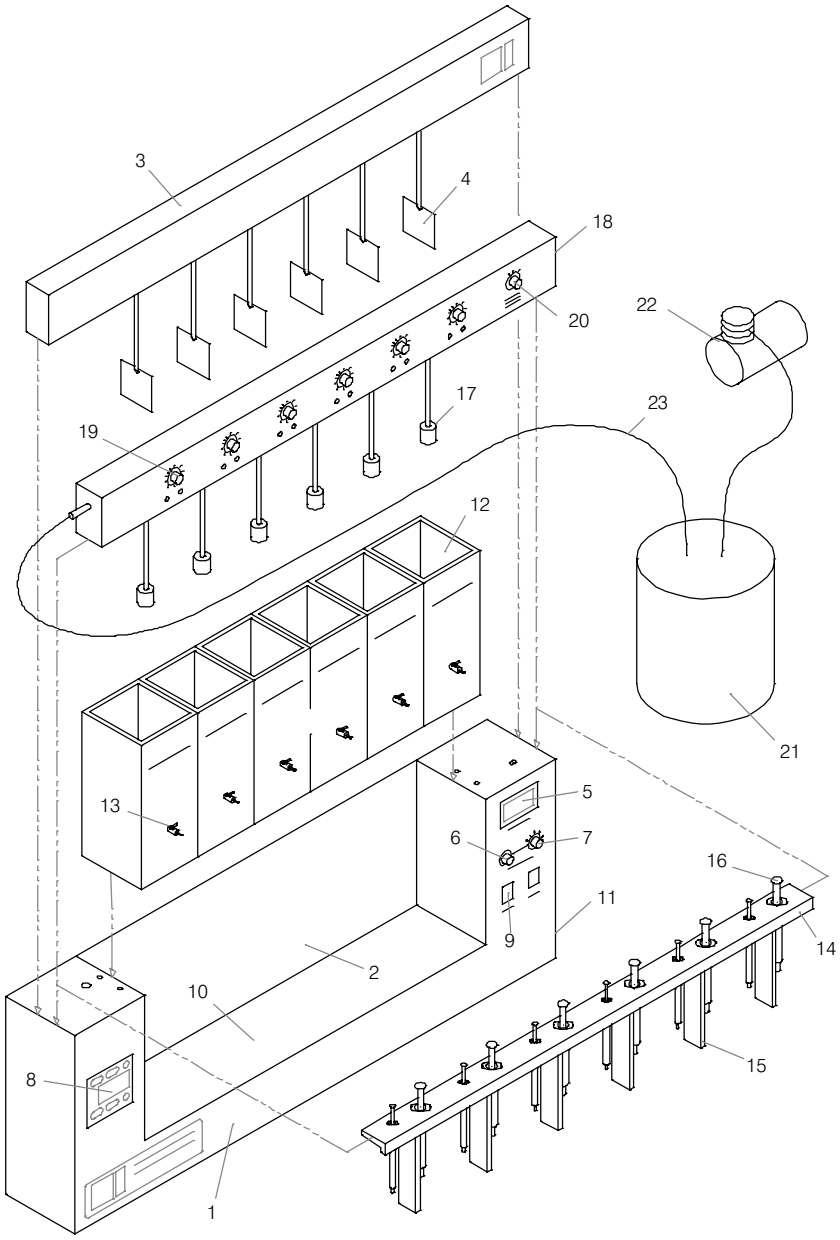
The mixer module (**3**) contains the paddle assemblies (**4**) and the paddle drive system. The module can be removed from the base and sample jars as a single unit, simply by lifting it off.

Mixer speed is indicated by the digital tachometer (**5**) and is adjusted by means of a continuously variable control (**6**) or five switch-selectable, adjustable preset speeds (**7**). A digital clock with dual alarm count down/ count up timers (**8**), and switches for the mixer, recycle module, light, and fan (**9**) are built into the base unit.

A high-intensity dual-tube fluorescent lighting system (**10**) is built into the base. The good lighting and close jar spacing make it easy to document test results photographically.

The built-in internal cooling fan (**11**) greatly reduces the possibility of misleading results caused by sample heating.

One-litre square acrylic sample jars (**12**) are used, with subsurface sampling being done by means of a miniature quick-connect stopcock system (**13**).



The DBT system uses a removable module (**14**) with baffles (**15**) and chemical dosing syringes (**16**). The baffles prevent vortexing and air entrainment at the high mixing intensities available, and the syringes allow accurate, simultaneous dosing of chemicals to all jars.

Recycle water is injected into the jars from the top. The injection systems and nozzles (**17**) for all six jars are contained in a single module (**18**) which is placed on the base when recycle injection is required, and lifted off immediately afterwards.

The recycle module contains individual adjustable electronic timers (**19**) and solenoid control valves for each station, and a three-position switch (**20**) for selection of various recycle injection modes. The module is automatically supplied with 16 volt DC power when it is placed on the base.

Supersaturated recycle water is provided by an 8-litre stainless steel certified pressure vessel (**21**) with access hatch, pressure gauge, safety relief valve, and quick-connect air and water fittings.

The saturator is partially filled with water, then pressurized to about 80 psi with the compressor (**22**) supplied with the system. The vessel is shaken for a short time to saturate the water, and the recycle injected into the sample jars through the recycle line (**23**). After recycle injection, the mixer and recycle modules are removed from the base, and the desired tests carried out on the water samples.

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DBT6 DISSOLVED AIR FLOTATION BATCH TESTER

MAIN FEATURES

2. Equipment description

2.1 Main components

The main components of the DBT6 system are shown in the diagram. These are:

1. Base unit. This consists of the jar support base with end housings, mixer drive motor, mixer speed controls and indicator, fluorescent lamp, cooling fan, 16V DC power supply, and controls.

2. Sample containers (jars). Six individual sample containers are supplied with the DBT6. Each jar is graduated at the 1 L mark and with 5% volume increments. Sample ports, with removable stopcock, cap, adapters, and tubing, are provided.

3. Dosing/baffle module. This serves two functions. The first is to provide baffling in the jars, to prevent vortexing at high mixer speeds. The second is to provide a holder for chemical dosing syringes, so that chemicals can be added simultaneously and accurately to all jars.

4. Mixer module. This consists of six paddle/shaft assemblies, with drive system and coupling. It is placed on the base unit during the mixing stage of the test procedure, and automatically coupled to the mixer drive motor.

5. Recycle module. The recycle[2] module contains six individual recycle injection systems, one for each jar station. Each system includes a solenoid valve controlled by a timer, to allow preselected amounts of recycle to be added. A selector switch provides a choice of three different recycle injection modes. The recycle module is automatically connected to 16 volt DC power when the module is placed on the base unit.

6. Recycle saturator. The stainless steel saturator vessel provides the supersaturated water used for recycle injection. It is provided with fill hatch and cover, air inlet and water outlet connections, pressure gauge, and pressure relief valve.

7. Air compressor. The air compressor is used to pressurize the recycle saturator to the 60 to 80 psi (400 to 550 kPa) typically used in dissolved air flotation processes.

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[2] The term “recycle” is universally used to describe the supersaturated water that is added to the sample jars, even though it is normally not recycled from anything and is therefore usually incorrect. The term is used because this water corresponds to the supersaturated effluent recycle stream that performs the same function in full-size DAF treatment plants.

8. Carry cases. The DBT6 is packed in two carry cases:

    - Basic equipment. The first case contains the components necessary to carry out conventional (non-DAF) jar test procedures - base unit, mixer module, and jars (six individual jars or one six-pack). The DAF recycle injection module is also carried in this case when needed.

    - DAF components. The second case contains the additional equipment (recycle saturator and air compressor) needed for DAF testing. There is also space for miscellaneous items such as syringes and stock chemical bottles. The recycle module, also needed for DAF work, is carried in the main case. The baffle / dosing module can be carried either in this case, or in the main case if the recycle module is not needed.

    The cases are reasonably rugged and are provided with internal foam rubber padding where appropriate, so the equipment is fairly well protected. Nevertheless, they should be handled with care when being transported and when the equipment is being packed or unpacked.

Following are some details on these components.

2.2 Base unit

Components

The base unit includes:

- The main structure (jar support base, end housings, and back plate). The two end housings have removable covers for access to the internal components.
- On/off switches for mixer and light
- Mixer drive motor with speed controller, digital tachometer, and shaft coupling
- Fluorescent lamp and ballast
- Cooling fan
- 16 volt DC power supply for motor, controls, tachometer, and recycle module
- Built-in combination dual count down / count up digital alarm timer and clock
- Mixer speed control and preset speed selector switch
- Power cord receptacle with fuse holder

Base unit controls

The controls on the base unit are:

1. Mixer on/off switch. To operate the mixer, this switch must be in the "on" position. When the mixer is not in use, this switch should be left in the "off" position, rather than simply turning the motor speed control to a very low setting. This switch also controls power to the recycle module.

2. Light on/off switch. This switch controls the built-in fluorescent lamp in the base unit, and the cooling fan. The fan runs whenever the lamp is on.

3. Mixer speed presets selector. This control allows selection of any one of five preset mixer speeds (see Item 4 below) or the continuously-variable speed adjustment control immediately to its left.

4. Preset mixer speeds. Five adjustable preset mixer speed settings are provided. The speeds are adjusted by means of a small screwdriver inserted through the front panel holes at each of the five locations. Normally, the speeds would be set to those most commonly used, and changed only infrequently. In potable water testing, for example, typical preset speeds might be something like 300, 60, 45, 30, and 20 rpm.

5. Continuously-variable speed control. This control provides continuously-variable speed adjustments from minimum speed (about 10 rpm) up to maximum (about 300 rpm with the baffle installed). If this control is preferred over the presets for slower speeds, it may be convenient to adjust Preset 1 to give the desired high speed. The selector knob can then be used to switch between high speed (for coagulant addition) and slower speeds (for flocculation) without the need to vary the continuous adjustment control over its full range each run.

6. Clock/timer. The built-in clock/timer has two independent count-down / count-up alarm timers, in addition to a digital clock.

   Select one or other of the timers, or the clock, using the selector buttons near the top of the timer.

   Set countdown times using the hours, minutes, and seconds buttons (holding any of these buttons down causes its count to continuously increase). Press the Start/Stop button to start the count-down period. After the count-down time has elapsed, the alarm will sound (for one minute unless silenced) and the timer will start to count up. If no countdown time is set, the timer will start counting up as soon as the Start/Stop button is pressed. Both timers can be used simultaneously and independently.

   Pressing the Start/Stop button after the countdown time has elapsed will silence the alarm. Pressing it again will recall the countdown time previously set. Pressing it a third time will re-start the count-down period.

To set the clock time, press and hold down the Clock button until the display starts flashing (about three seconds) then set the time using the H, M, and S buttons. Press the Clock button again to return to normal operation. To change between am/pm and 24-hour time, press and hold the Stop/Start button.

2.3 Sample jars

The DBT6 system uses one-litre sample containers (jars), supplied as standard equipment. Additional jars or fittings are available separately.

The threaded adapter supplied with each jar is inserted into the sample port on the front of the jar, snugly tightened, and normally left permanently in position. Depending on whether subsurface sampling is required, either a stopcock or cap (both supplied with each jar) is attached to the threaded adapter. Usually, the stopcock would be used, together with the supplied tubing adapter and sample tubing.

2.4 Baffle/dosing module

The baffle/dosing module serves two functions. The first is to provide baffling in the jars, to reduce vortexing and air entrainment at high mixer speeds. The second is to provide a holder for chemical dosing syringes, so that chemicals can be added simultaneously and accurately to all jars.

The module is designed to use standard 1 mL and 5 mL syringes (included with each jar) for chemical dosing. It can hold one syringe of each size for each of the six stations. The syringes are filled with the appropriate amounts of each chemical to be dosed, and inserted into the module. This is then placed on the base unit, the mixer is started, and the chemicals dosed to all six stations simultaneously. The baffle/dosing module can be removed from the base unit after the mixer speed has been reduced, or chemical dosing has been completed.

2.5 Mixer module

Components

The mixer module consists of:

- Aluminum base and housing
- Drive shaft and bearings

- Six stainless steel vertical-shaft paddles, one for each station
- Motor shaft coupling
- Miter gears between vertical and horizontal shafts.

2.6 Recycle injection module

Components

The recycle injection module consists of:

- Aluminum base and housing
- Six solenoid valves, each connected to a recycle injection tube and nozzle
- Internal recycle water piping and external recycle inlet quick-connect fitting
- Individual solenoid valve timers, on/off switches, and start buttons
- Timer mode selection switch.

Power supply

The recycle injection module is supplied with 16 volts DC from the base unit. The use of low-voltage DC power avoids the potential hazards of mains voltages in the vicinity of pressurized water-containing systems. The 16 V DC power connection is automatically made when the recycle module is placed on the base.

The module contains individual on/off switches for each air injection station. Except when being used for recycle injection, these switches should be left in the "off" position. This will ensure that there are no unintended discharges of recycle water resulting from initial connection of power, accidentally pressing a start button, or some other cause.

Recycle selector switch

The recycle selector switch (on the right front of the recycle module) provides three different control modes for the air injection system:

1. Independent systems. Each of the six stations operates completely independently of the others. The recycle injection time is set for each station using its own timer, and started using its own start button. This setting would probably not be used as much as the other two, but is useful in special circumstances or when only one or two stations are being used.

2. Common timer. A single timer and start button controls recycle injection to all stations. This mode is often used when assessing the effects of different process conditions (such as coagulant dosage) with identical recycle injection into each jar. For convenience, each of the six timers could be set to different times, and the one to use for a particular run selected simply by choosing the appropriate start button. This would probably be the most commonly-used setting for most jar testing procedures.

3. Common start. The recycle injection time for each station is set using its own individual timer, but all stations are started simultaneously by pressing any start button. This setting is useful when using different amounts of recycle in each jar, and the same start time for all.

Injection tubes

Recycle water is injected into the jars through injection tubes on the solenoid valve discharges. Each tube is fitted with an injection nozzle at its lower end, where the actual pressure reduction and bubble formation takes place. The discharge orifices are located within the nozzle housing, which provides the impingement surfaces needed to enhance bubble formation and prevent excessive velocities which could break up floc particles.

The amount of recycle water injected will depend on:

- the size of the injection nozzle orifice
- the air pressure in the saturator at the start and end of injection
- the length of time the recycle valve is open
- the number of stations in operation.

Various other factors such as water temperature do have a slight effect on the volume of recycle water that will be injected but these are usually negligible.

The standard injection nozzle orifice size provided with the DBT6 is 1.2 mm. This size has been selected to inject a recycle volume of about 120 mL (12% of the jar sample volume) at the maximum timer setting, a saturator pressure of 70 to 80 psi, and all six stations in operation. Fewer operating stations will result in somewhat greater flow from each. A typical recycle ratio for potable water systems would be about 8 to 10%.

If an unusually high recycle ratio (more than about 12%) is required for some reason, this can be easily achieved by injecting a second recycle amount immediately after the first. This could be done in various ways. The simplest would probably be to set the timers to give half the desired total recycle amount, then pressing the Start button a second time (as soon as the first injection has ended). In this way, a recycle ratio of up to about 25% can be achieved.

The recycle timers are graduated from 0 to 10. The graduations correspond roughly to seconds, but the actual valve open time is of little relevance to the recycle injection phase.

If desired, calibration checks could be carried out under various operating pressures and conditions, to determine the exact settings that should be used to provide a desired recycle injection volume. However, this volume can easily be read using the incremental 5% calibration marks on the jars, which will be accurate enough for most purposes. Bear in mind that air quantity, above a certain minimum, is not usually a very significant variable in evaluating DAF processes.

We should point out here that it is impossible to achieve exactly equal discharge volumes from all of the six injection nozzles in the recycle module. We calibrate each individual nozzle in a special test fixture and attempt to match nozzles so that discharge volumes for each station are as close as can realistically be achieved. Generally, we are able to match flows to within 5% of the average, and this is more than accurate enough for almost all work likely to be done with the DBT6. If greater accuracy is desired for some special reason, calibration tests should be carried out on each individual nozzle and actual measured discharge rates used.

2.7 Recycle saturator

The recycle saturator consists of:

- Stainless steel pressure vessel (8 litre capacity, 190 psi Maximum Allowable Working Pressure), with removable quick-lock hatch for filling and emptying. A copy of the manufacturer's Certificate of Compliance for this pressure vessel is included at the end of this manual.
- Pressure gauge (0 to 100 psi)
- Pressure relief valve (permanently set to relieve at 140 psi)
- Quick-release couplings for air inlet and water outlet lines.

To connect the quick-release couplings on the recycle line (between the air saturator outlet and the recycle module inlet) hold the part of the body fitting connected to the tube (not the enlarged sleeve) and press firmly into the receiving fitting until a distinct click is heard. To release, grip the sleeve and pull towards the receiving fitting. Residual pressure in the saturator vessel can be relieved by pulling upwards on the relief valve pull ring. This also serves to exercise the relief valve and reduce any possibility of sticking.

2.8 Air compressor

Because individual users' circumstances and requirements vary, a compressor may or may not be provided with the DBT6. Any small compressor capable of providing a pressure of about 100 psi (700 kPa) may be used. An air hose with a standard ¼-inch NPT fitting at

one end (for connection to the user's compressor or air supply) and a quick-connect fitting at the other end (for connection to the saturator) is supplied with the DBT6.

For portable applications, we suggest the use of a compact air compressor that will fit in the space provided in the recycle saturator carry case. This type of unit is supplied with the DBT6 when included.

The following notes apply to the compressor normally provided with the DBT6 system, when a compressor is included in the supply.

The compressor has a rated capacity of 0.7 cfm at 90 psi, a maximum pressure of 100 psi, and an air storage tank capacity of 2 USgal (8 L). It is the oil-less type and requires no lubrication.

When powered, the compressor will start and stop so as to automatically maintain the pressure in the storage tank between 70 and 100 psi. The compressor will start when the storage tank pressure drops to 70 psi, and will stop when it rises to 100 psi. These start and stop points are not adjustable.

An internal fan inside the compressor housing will start and stop automatically, as required for compressor cooling.

The air supply line from the storage tank is equipped with a pressure regulator, to allow any desired discharge pressure between 0 and 100 psi to be set. The selected pressure will be automatically maintained, except when air demand is higher than the system's rated capacity or if the storage tank pressure drops below the selected pressure.

Additional information is provided in the compressor manufacturer's booklet entitled *Operating Instructions and Parts Manual*.

For normal use with the DBT6, we recommend that the pressure regulator be set at 70 psi.

The air discharge line from the compressor unit can be left connected to the saturator vessel during jar testing procedures, so that the pressure in the saturator remains constant even after recycle withdrawals. Before disconnecting the air line (to refill the saturator with water, at the end of the day, or for some other reason) be sure to close the ball valve immediately downstream of the regulator. If this is not done, pressure in the air storage tank will be lost.

2.9 Carry cases

The DBT6 is packed in two carry cases. Please note that these cases are designed for light to moderate duty only, and a reasonable degree of care in handling - such as would typically be provided by actual users of the equipment - is required. The cases are not intended for frequent shipping by commercial carriers, who unfortunately often subject their shipments to extremely rough and careless handling. If frequent shipping of the DBT6

system by commercial carriers is required, we recommend that heavy-duty cases be used. These are obtainable from custom case fabrication companies at fairly reasonable cost.

Main case

The main case contains the components necessary to carry out conventional (non-DAF) jar test procedures - base unit, mixer module, and jars. This case also accommodates the recycle module or baffle/dosing module, as needed.

This case contains most of the relatively delicate equipment and should therefore be carefully packed, unpacked, and handled. The equipment is well padded and protected, but should still be handled with reasonable care.

Unpacking

1. Stand the case vertically (handle up) on a solid, clear, flat surface.

2. Remove the three hasp locking pins and carefully open the hinged front, laying it flat on the work surface.

3. Remove the foam pads from the front, top, and two ends of the equipment.

4. Carefully reach inside the case and grasp the main (base) unit, around the ends. Gently pull the base unit, together with the attached recycle and mixer modules, out of the case and place it on the work surface. Note that the base unit with mixer, recycle module, and jars, is fairly heavy - about 34 lb (16 kg).

5. Remove the shipping tape (if present). Lift the recycle and mixer modules off the base and place them on the work surface. Remove the jars, saving the separator pieces for possible reuse.

6. Plug in the power cord at the back of the base unit. The unit is now ready for use.

Repacking

Repacking the case for transportation is basically the reverse of the unpacking procedure described above. Use care in repacking, and ensure that all components, foam rubber packing, and separators are in their proper places. Insert the hasp locking pins.

DAF case

The DAF case contains the additional equipment needed for DAF testing - the recycle saturator vessel and (if needed) the air compressor. There is also space for miscellaneous items such as air and recycle hoses, syringes, sample bottles, and stock chemical bottles. (The recycle module, also needed for DAF work, is carried mounted on the base unit, in the main case.)

The saturator and compressor are relatively rugged compared to the other components, and no special unpacking or repacking procedures are required. Nevertheless, reasonable care should still be taken in handling them.

The baffle / dosing module can be carried either in the DAF case or the main case, depending on whether DAF capability is required. If it is, the recycle module is carried in the main case, mounted on the base unit in the normal way. The baffle / dosing module is then carried in the DAF case, in the location provided for it. If DAF capability is not required in a particular situation, the recycle module can be removed from the base unit and the baffle / dosing module carried in its place, mounted on the jars in its normal position.

3. Jar test procedures

The basic objective of the DAF batch (jar) testing procedure is to simulate, as far as is practical, the processes that are being, or might be, used in a full-scale treatment plant. Because there are fundamental differences between batch and continuous flow processes, the jar test does have its limitations. Nevertheless, it can prove very useful as a simple, rapid, and economical means of evaluating how well the DAF process can be expected to work, and in determining certain process parameters such as chemical dosages, reaction times, and air requirements.

Of course, each situation will be unique, with its own circumstances and objectives. Therefore, only a simplified, general test procedure can be given; this must be modified as required by the specific situation.

Following is a suggested basic DAF jar test procedure.

1. Insert the desired fittings (either a stopcock or a cap) into the sample ports of one or more of the six square 1 L containers (jars). Both types of fitting are inserted into the screwed adapter on the jars with a quarter to half turn, until snug - do not over-tighten.

   The supplied tubing adapter and sample tubing may be inserted in the discharge side of the stopcock, if desired. If depth sampling is not required, use of the caps instead of the stopcocks will make handling a little easier and will reduce the likelihood of breakage.

2. Fill the jars to the 1 L mark with the water being tested. Place the jars in position on the base.

3. With the mixer motor switch in the "off" position, place the mixer module onto the base. Make sure it is firmly and properly seated. It may be necessary to “jog” the mixer motor slightly, with the speed at a very low setting, to align the coupling parts and allow the mixer bar to drop into place.

4. For each of the test stations being used, fill syringes with the appropriate amount of stock chemical (such as alum coagulant and/or polymer) and insert these into the holes in the baffle/dosing module. Place the module in position on the jars.

5. Start the mixer motor and set it to the desired speed (usually full speed for the coagulant addition stage). For operation at full mixer speed, the baffle/dosing module should be used; otherwise, the contents of the jars may be subject to excessive vortexing and air entrainment.

6. Inject the chemicals by pressing down on the syringe plungers. All six stations can be dosed virtually simultaneously. For simulation of the short, high-intensity "flash mixing" often used in coagulant addition, the mixer speed should be reduced after a time corresponding as closely as possible to the actual mixing time that would be

used in a full-scale plant. In many cases, this would be almost immediately after coagulant addition.

7. The baffle/dosing module can be removed, if desired, as soon as the mixer speed has been reduced to below about 200 rpm. Subsequent addition of chemicals such as polymers is not as critical as the initial coagulant addition, and does not require the use of the dosing module.

8. Set the mixer speeds to provide the mixing intensity desired for the first flocculation stage. One or more of the five preset speeds can be selected, or the continuously-variable control can be used. The preset speeds are adjustable by means of a small screwdriver (provided with the DBT6) inserted through the holes in the front panel at each location.

9. Note that mixer speeds may vary slightly from time to time because of factors such as different number of jar stations in use, temperature variations, etc. These small variations are normal and will not affect the results of the jar test in any significant way.

10. Set and start the built-in count-down timer.

11. Turning on the lamp in the base of the unit will greatly improve observation of floc formation and other processes taking place. In most cases, a black background will be best for observing particles in water contained in the jars. However, for some processes (such as color removal) a white background will be more appropriate; in these cases, simply insert the supplied white plastic curtain sheet behind the jars.

12. At the end of the first flocculation time period, adjust the mixer speed and reset the timer. Repeat as appropriate for the number of flocculation stages desired.

13. During the flocculation period is often a good time to prepare the recycle injection system. Fill the saturator vessel about two-thirds with water (to approximately the upper weld on the 8 L vessel). Too little water would mean that the vessel has to be refilled more often, and too much may result in the pressure dropping excessively during a recycle injection sequence because of the reduced air space. If the compressor used to supply the air has its own storage tank and pressure regulator, or a pressure-regulated piped air supply is used, the saturator vessel can be filled to a somewhat higher level.

    The quality of the water used for the recycle is important:

    - It must be free of solids that could plug the recycle orifices (which are 1.2 mm diameter). Soft particles such as floc that can be easily broken up are not a problem, but harder debris such as sand or pieces of vegetable matter should be avoided. If relatively large solids are present (or can be expected from time to time), the water should be strained. This can be done simply by pouring it into the saturator through a piece of mesh or similar material.

- The chemical composition should be such that it does not change the chemistry of the water being tested significantly. Ideally, the recycle would be the effluent from a previous run using the same raw water (filtered or strained if necessary to remove large solids). This would most closely simulate the situation in an operating plant. Or, if the jar test is being run at an existing plant that is treating the same raw water using similar chemical dosages, a good source would probably be the clarified or filtered water from the plant. Finally, if no other suitable source can be found, distilled or deionized water could be used.

14. Close the saturator access hatch. Connect the air compressor line and pressurize the saturator vessel to about 2 to 4 psi (15 to 30 kPa) above the desired starting pressure (the pressure will drop slightly as the air dissolves in the water). Usually, the starting pressure would be in the 70 to 80 psi (480 to 550 kPa) range, and will drop 5 to 10 psi (30 to 60 kPa), depending on the amount of recycle used and the air/water proportions in the saturator during the recycle injection. The vessel can be repressurized with air before the next run, if there is sufficient water left in it. Alternatively, if a constant-pressure air supply is available (such as from a compressor with an air storage tank, or a piped air supply) the air supply may be left connected to the saturator so that its pressure remains constant during the recycle injection.

15. Shake the vessel for 10 to 20 seconds to saturate the water with air.

16. Make sure all the switches on the recycle injection module are in the "off" position. Place the module on the base, and connect the recycle line (the 6 mm diameter blue polyethylene tubing with quick-connect fittings at each end) to it. Connect the other end of the recycle line to the saturator vessel.

17. Before each session, or if air has been introduced into the recycle system, the solenoid valves should be opened briefly to flush the system. This is best done by placing small containers under each of the injection tubes, and opening the valves (with the recycle selector in the "common timer" mode) for a second or two.

18. Make the desired settings on the recycle injection mode selector, the injector on/off switches, and the injection timers.

19. Inject the recycle water into the jars by pressing the injection timer "start" buttons, as appropriate for the injection mode selected. At the start of injection, there may be a few large bubbles of air resulting from unpressurized water left in the injection tubes (between the solenoid valves and the orifices) from the previous run or from air trapped in the nozzle itself. The quantity of this water and air is negligible (the water volume is less than 2% of a typical recycle addition) and can be ignored.

20. Continue to operate the mixer during recycle injection. As soon as injection has been completed, stop the mixer. Remove the mixer and recycle injection modules from the base.

21. Carry out observation, sampling, and evaluation procedures as desired.

A note on turbidity measurements

The presence of air bubbles in any water sample will result in positive interference with turbidity measurements – that is, the measured turbidity will be higher than the true turbidity. This can happen even if the air bubbles are not visible to the naked eye.

The problem can occur with any sample or treatment process, under certain conditions. With dissolved air flotation, the likelihood of samples being saturated or supersaturated with air is greater than with conventional processes and the presence of air bubbles in samples is a very real possibility.

Therefore, take care to ensure that air bubbles are not interfering with turbidity measurements. Usually, such interference will be indicated by erratic or inconsistent turbidity readings, or readings that change if the sample is allowed to sit for a few minutes.

The problem is easily overcome. All that is necessary is to degas the sample, by applying a partial vacuum for a few seconds. Take a rubber stopper that fits the top of the turbidity sample vial, and which has a hole to fit the nozzle on an ordinary 5 mL or 10 mL syringe. Insert the syringe into the stopper, and the stopper into the sample vial. Pull up on the syringe plunger and hold it there for a second or two. There will probably be some bubbling in the sample, from dissolved gases being released. Remove the stopper from the vial, allow the sample to sit for a few minutes, and measure turbidity. This procedure takes just a few seconds for each sample.

It is worth spending a little time experimenting to see whether this problem does in fact exist in a particular situation. If it does not, there is no point in carrying out the degassing procedure. If it does, a few trial runs will quickly indicate the most appropriate procedural details needed to obtain accurate, reliable, and consistent turbidity measurements.

4. Maintenance

4.1 General

The DBT6 requires very little maintenance, other than cleaning, occasional minor lubrication, and replacement of items such as lamps and timer batteries.

4.2 Cleaning

The unit should be cleaned up immediately after each run, particularly the jars. If solids such as floc are allowed to dry out on component surfaces, they may be much more difficult to remove later. Rinse with clean water, or wipe down with a damp cloth, as appropriate. ***Do not use organic solvents such as acetone or alcohol, which may damage plastic surfaces or paint finishes.***

4.3 Lubrication

All bearings in the DBT6 system are oil-impregnated bronze, and should require lubrication only very occasionally.

If the drive system seems rough or noisy, a small amount of light oil could be applied to the paddle shaft bearings in the mixer module. Lay the module upside down on a flat surface, and place a drop of oil on the bearings where the mixer shafts enter. Rotate the mixers by hand a few times to distribute the oil, and wipe off any excess.

If the paddles become difficult to turn, the internal drive shaft bearings may need lubrication. Remove the screws holding the back cover to the base, and lift the cover off. Apply a small amount of light oil to the bearings, rotate the paddles to distribute the oil, and wipe off any excess. Replace the cover and screws. This procedure should be necessary only very rarely, if ever.

4.4 Recycle nozzle cleaning

Care should be taken to ensure that the water used for recycle does not contain solids that could plug the small (1 mm diameter) injection nozzle orifices. If these orifices do become plugged for some reason, they can be cleared by placing the recycle module on the base

unit, into jars containing clean water. Then, apply suction to the recycle inlet connection by means of a vacuum pump or similar device, and open the solenoid valves using the recycle module controls. Any solids in the nozzles should be removed by the water flowing through them in the reverse direction. It is best to avoid having to carry out this procedure, by ensuring that only solids-free water is used for the recycle.

4.5 Fuse replacement

The electrical system of the DBT6 is protected by a 2 amp fuse, located in the small drawer underneath the power cord receptacle. To replace the fuse, remove the power cord and pull out the drawer using a small flat-blade screwdriver in the slot at the top of the drawer front. A spare fuse is supplied with the DBT6, and is located in the fuse drawer immediately in front of the active fuse at the rear. Insert the new fuse, close the drawer, and plug in the power cord.

If the fuse blows repeatedly, have the electrical system checked by a qualified electrician.

4.6 Lamp replacement

The fluorescent lamp in the DBT6 unit has a rated life of 20,000 hours, equivalent to over 50 years' operation at an hour each day. Therefore, it should very seldom be necessary to replace the lamp. However, if this has to be done for some reason, follow these steps:

1. Remove the end cover plates from the base unit (four screws each side).

2. Place the base unit on its back and remove the two screws on the bottom which secure the lamp socket.

3. Gently pull the lamp socket and lamp outwards (towards the right side of the unit) enough to allow the lamp to be grasped. The four wires between the ballast and the lamp socket can be temporarily disconnected, if desired, to make removal of the socket easier. Unplug the lamp from the socket (a gentle pull is all that is needed) and plug in the new lamp[3].

4. Notice that there is a lamp support clip near the bottom left end of the base unit, below the diffuser. Push the lamp / socket assembly back into the base of the DBT6 until the lamp is felt to engage the support clip.

[3] Lamp is 50 watt compact fluorescent type with 2G11 base (Osram Sylvania Dulux L, GE Biax, or equivalent)

5. Align the lamp socket with the screw holes in the DBT6 base, and replace the screws.

4.7 Timer battery replacement

The built-in timer is powered by a 1.5 volt alkaline button cell (GPA76 or equivalent) which should last for several years in normal use. If the timer display becomes dim, the cell should be replaced. To do this, remove the left side cover plate from the base unit. Use a coin or other tool to remove the small circular battery cover on the back of the timer unit. Install the new cell and replace the battery cover and right side cover plate. Set the current time as described in Section 2.

4.8 Tools

Most of the screws used in the DBT6 are the Robertson (square drive) type. Although these screws should rarely need to be removed, a screwdriver handle and set of Robertson bits (plus various other types of bits) has been included with the DBT6.

Also included is a small screwdriver-type tool for adjusting the mixer speed presets.

5. Specifications

Base unit and mixer

Number of stations	6
Sample container volume	1 L
Mixer speed range	10 to 300 rpm (approx.)
Maximum power consumption	1 amp (including recycle module)

Recycle system

Typical working pressure	400 to 550 kPa (60 to 80 psi)
Maximum working pressure	700 kPa (100 psi)
Saturator volume	8 L
Recycle injection ratio	0 to 12% (approx., single injection)
Orifice size	1.2 mm
Recycle injection rate	12 mL/s (approx.)

Dimensions

Base unit with mixer and recycle modules	780 x 350 x 130 mm (31 x 14 x 5 in.)
Main carrying case	840 x 420 x 195 mm (33 x 16½ x 7¾ in.)
Main carrying case with shipping carton	860 x 440 x 210 mm (33¾ x 17¼ x 8½ in.)
DAF carrying case	735 x 410 x 280 mm (29 x 16¼ x 11 in.)
DAF carrying case with shipping carton	760 x 440 x 290 mm (29¾ x 17¼ x 11½ in.)

Weights

Main case

Base unit	6.9 kg (15 lb)
Jars (6)	3.1 kg (7 lb)
Mixer module	2.3 kg (5 lb)
Recycle module	3.1 kg (7 lb)
Case	7.8 kg (17 lb)
Main case with equipment	23.2 kg (51 lb)
Main case shipping weight	24.0 kg (53 lb)

DAF case

Saturator vessel	4.7 kg (10 lb)
Compressor	8.9 kg (20 lb)
Accessories	1.4 kg (3 lb)
Case	8.2 kg (18 lb)
DAF case with equipment	23.2 kg (51 lb)
DAF case shipping weight	24.0 kg (53 lb)

MIXING INTENSITY vs PADDLE SPEED
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