TECHNICAL NOTES

October 2010

IBC Energy Saving Technologies

MULTIPLE BOILER SYSTEMS

Version 2.0

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IMPORTANT: This memo applies only to boilers with software versions 2.23.1 and later.
For boilers with earlier software versions, refer to "Technical Notes - January 2009, Multiple Boiler Systems Version 1.0"

Introduction

The use of multiple condensing boilers for large input systems is an economical and easy way to upgrade older, inefficient boiler plants to attain outstanding energy savings. In new construction, as well, these boilers provide buildings with the highest heating system efficiencies possible. The advantages are numerous.

From the installation viewpoint, using "off the shelf" boilers in place of large custom order commercial products can save considerable money, and eliminate the often lengthy lead times required for manufacturers to order, fabricate and ship their product to the site.

Custom commercial boilers often require cranes and other specialized moving equipment and usually require hiring welders, millwrights and other high value trades to complete the installation. The smaller size of the IBC wall mounted condensing boilers, means that in most cases the boiler room equipment can be moved into place and installed without special equipment using the mechanical contractor's in-house staff.

Other boiler room components such as pumps, valves, fittings, hydronic specialties and venting components are also "off the shelf" equipment that can normally be readily sourced from local plumbing & heating wholesalers.

From an operational point of view, the story even gets better. Please refer to our IBC "Multiple Boiler Case Studies" brochure for some real world examples of the exceptional savings to be had from these types of installations.

Multiple IBC modulating, condensing boilers give the boiler plant an incredible "turn down" capability to respond to any building load condition imaginable. Four IBC 45-225 boilers for example will allow load matching from an input of 45,000 Btuh all the way up to 900,000 Btuh. This "right sizing" to building load, increases energy savings dramatically. It is not uncommon to see fuel savings of over 50% in retrofit situations.

Redundancy is also an important benefit of multiple boilers as individual boilers can be taken off line for service without impairing the operation of the rest of the boiler plant.

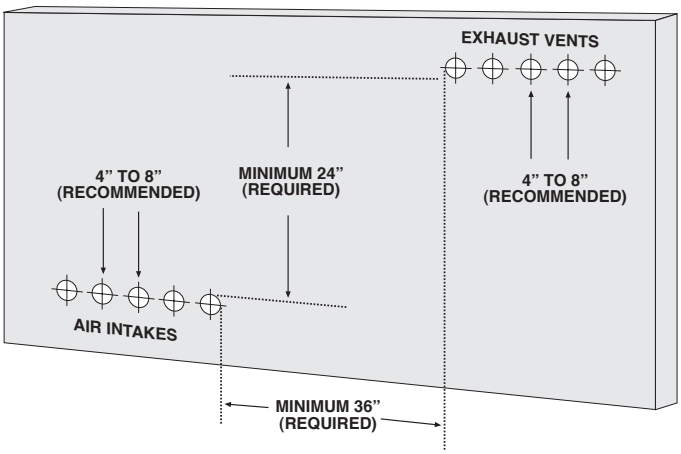
IBC's VFC 15-150 and 45-225 modulating models are set up for staging without any extra controls – all that is needed is a 2-wire, shielded-twisted pair connection between controllers and simple control settings using the keypads. One "master" unit acts as the server, with the other subordinate units switched via the network connection. Heat calls and load pumps are wired into the master. Control settings are made to determine the staging sequence (rotation or fixed lead), call up parameters (staging delay) and sensor readings.

Venting

The roof is recommended for vent termination, doubly so with multiple units where steam plumes can be that much larger than from singe units.
For sidewall applications, ensure a "sterile" wall is readily available (no windows, close neighbours), and ensure that should condensate drip from vent terminations, it will hot have adverse effects (including freeze-up) on objects or structures below.

For roof top penetration of multiple boiler sets, options

are to group all intake terminals together for a common penetration through a custom cap, or to place them in close proximity, using commonly available pipe flashing. Alternatively, these boilers are certified to be installed using indoor combustion air (adequate combustion air to the boiler room must be provided by other approved means). Group the exhaust pipes and place the 2 separate



groups (intake and exhaust) at least 3' apart. The closest intake and exhaust pipes shall be 36" or more apart. Ensure the outdoor combustion air intakes are downturned using 1 or 2 x 90° elbows. Exhaust termination pipes must be 24" minimum above the intake elevation whether roof or wall mounted.

Condensate removal

Do not common vent either intake or exhaust pipes. Flue gas condensate is mildly acidic. Condensate neutralization must be used when disposing condensate into drainage systems containing cast iron or copper pipe and fittings. In many buildings, the installer cannot be sure that cast iron or copper components have not been installed somewhere in the system. Although most municipalities will allow unmodified condensate to be drained directly into plastic sanitary drainage systems, we always recommend the use of acid neutralization for multiple boilers due to the larger volumes to be disposed of. In locations where large volumes of condensate are drained directly into a septic system, neutralization is also an important practice.

Piping

Use a Primary/ Secondary piping configuration as illustrated below.

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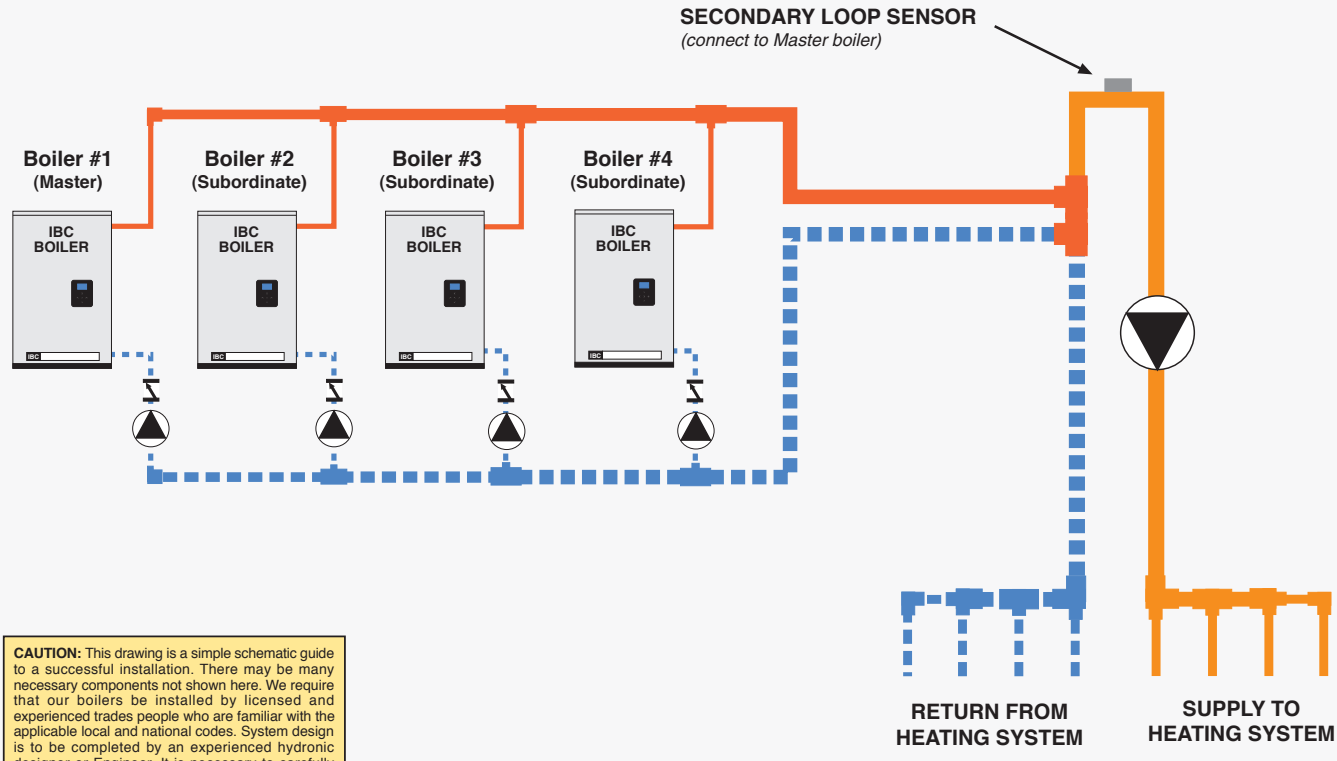
4 STAGED BOILERS SINGLE LOAD



CAUTION: This drawing is a simple schematic guide to a successful installation. There may be many necessary components not shown here. We require that our boilers be installed by licensed and experienced trades people who are familiar with the applicable local and national codes. System design is to be completed by an experienced hydronic designer or Engineer. It is necessary to carefully read and follow the installation instructions that come with the boiler along with the application drawing that fits your system.

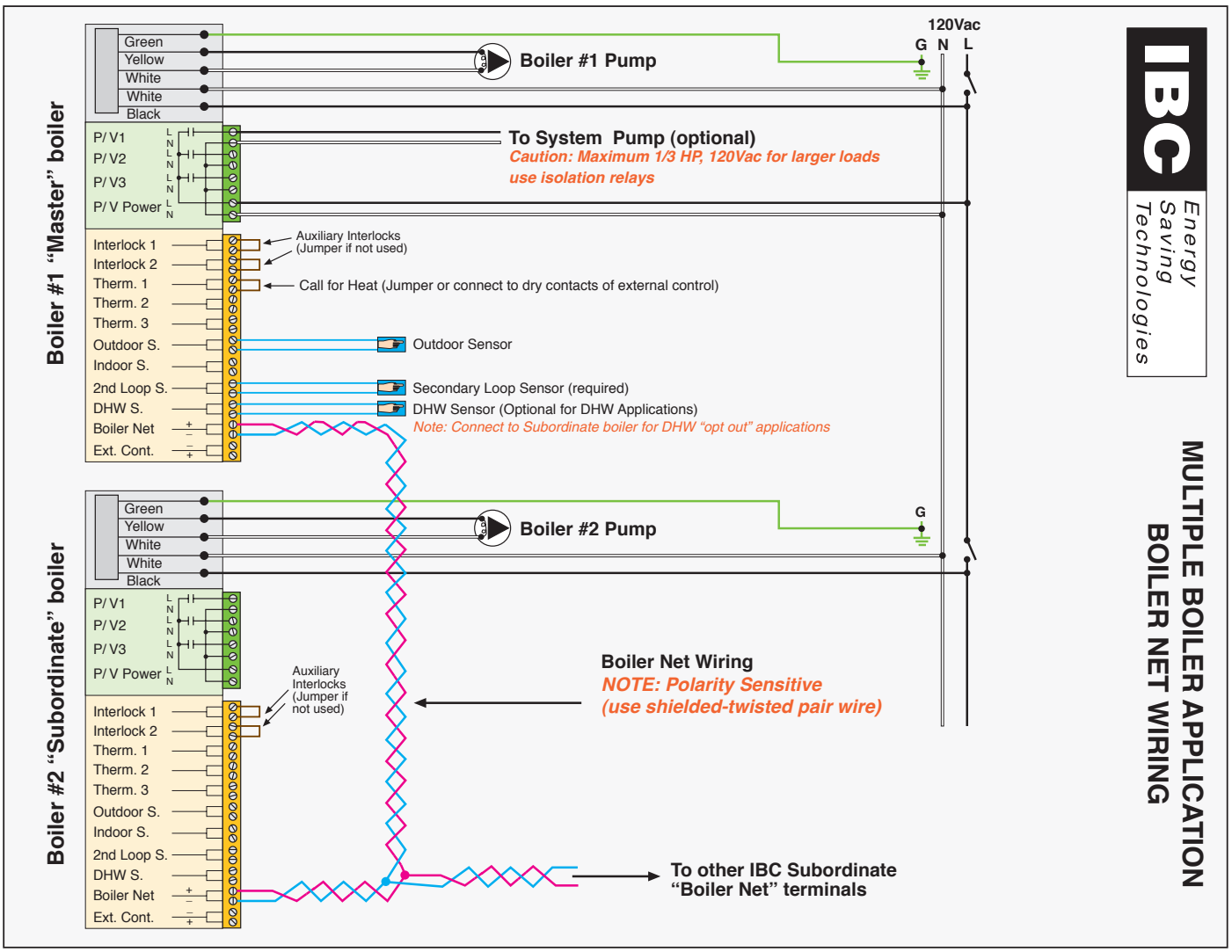
Important Note: Each boiler pump must be under the control of its own unit.
Each boiler attempts to perform a flow confirmation test prior to firing (VFC 15-150 and VFC 45-225 only); it looks for appropriate water pressure sensor readings while it cycles the pump on. If a boiler's pump is not under the direct authority of its corresponding boiler, an "error – no water flow" message will be given, and the boiler will go into a two minute retry cycle.

For optimum efficiency, and smooth operation in staging, we require multiple IBC boilers be placed in a parallel piping arrangement so that all units receive the same (cool) return water temperature, and unblended outlet boiler water is supplied to the building loop. See boiler piping schematics in this bulletin. Use check valves to prevent induced circulation through "off" units.

Control - General

There are several alternate methods for controlling a multi-boiler set:

1. The primary method involves identification of Master boiler which will receive all sensor and dry contact call-for-heat signals, manage any secondary pumps and via BoilerNet connection, supervise all subordinate boilers. This fully autonomous approach utilizes IBC's internal heat regulation and boiler management software.
2. The semi-autonomous BoilerNet option involves a remote analogue signal to the Master boiler's External Control terminals. This signal corresponds to a target set-point temperature, with the range



scaled according to the programmed min-max. IBC's multi-boiler heat regulation algorithm still determines which boiler fires, throttle levels etc, but to an externally determined operating temperature. Call-for-heat to the Master can be conveyed via a 1+ volt signal on the External Control terminal.

3. The third method is classic-DDC control, involving separate dry-contact calls and throttle control signals to each boiler. Note that IBC's heat regulation routine is subordinated to act solely in the limit protection role. Temperature regulation and boiler staging and rotation is handle over to the external DDC controller.

   Operational input can be delivered to each boiler via traditional methods (dry contact and external control inputs) or via IBC's BoilerNet Interface Controller. The BIC provides both web or BACnet/IP interfaces to IBC's boilers (all models). See BoilerNet Interface documentation.

   The majority of IBC multi-boiler applications use the full autonomous method above, and the remainder of this Memo focuses on this option.

   It is important to note that this is appropriate for a single load application, or some 2-load systems. Three-load sequential management strategy, popular on single boiler residential systems do not typically scale up to larger multi-boiler applications. Large systems imply significant thermal masses which generally cannot change temperature quickly; it is also a standard code compliance requirement to meet such commercial scale loads continuously.

   For continuous multi-boiler / multi-load applications, there are two options: (1) running the system at the highest demanded temperature, with mixing down for cooler demands, or (2) IBC's "DHW Optout" – oriented to run large space heating jobs (reset or set point) plus indirect DHW tanks on separate / parallel primary loops.

   If simultaneous multiple load running (other than the DHW Optout) is called for, eExternal building control systems or stand-alone mix down or injection devices must be used to meet cooler temperature loads.

Wiring

Inter-boiler / network connection:

Use polarity sensitive 2-wire leads (shielded twisted pair) to join one boiler to the next (to a maximum of 24 boilers). Connection is made between the "Boiler Net" terminals near the base of the orange terminal strip. Wiring between boilers need not be in any particular order, but good practice dictates a sequential "daisy chain" approach. See the wiring diagram below.

Boiler pump connection:

Wire each boiler's primary pump to that boiler's primary pump-flagged harness lead (yellow and white wires found in the wiring box behind the control); this must be done in order for each unit to carry out its own flow integrity test prior to firing.

Heating calls and secondary load pumps:

Bring all thermostat, sensor and secondary pump leads to one unit – typically the leftmost unit gets this treatment. This boiler will be declared as Unit 1 (Master boiler) in the software settings stage (below).

Settings

Those familiar with the IBC Multi-load software functions must note the following. It is important to be aware that the current multiple boiler operation at this time allows either for single load reset heating operation with domestic "opt-out", or for single load only.

If switching multiple loads such as reset heating, setpoint and domestic hot water on and off is required, controls such as building management systems or other external control systems such as tekmar's tN4 system must be utilized.

The external system will look after any necessary mixing functions and load pump switching, and can connect to the Master boiler through the "Therm. 1" contact input and the "Ext. Cont." input.

Sensors:

1. For Reset Heating functions, connect one of the supplied outdoor sensors to the Master boiler at the "Outdoor S" terminals. There is no need to link up the other boilers with the outdoor sensors supplied with those boilers.

2. DHW sensor – connect to the Master boiler ***only if the boiler plant will be dedicated entirely to DHW.*** Connect to opt out boiler(s) if opt-out option is to be used (see opt-out instructions further in this bulletin).

3. Secondary loop sensor – connect to Master boiler. Place a strap-on sensor (order from IBC or use a tekmar 071 sensor) on the building loop, downstream of the injection point from the boiler plant into the system piping loop.
   A secondary loop sensor is a primary control requirement for coherent management of a multiple boiler set.

The following pertains to IBC "on-board" control applications, not DDC/externally controlled boilers:

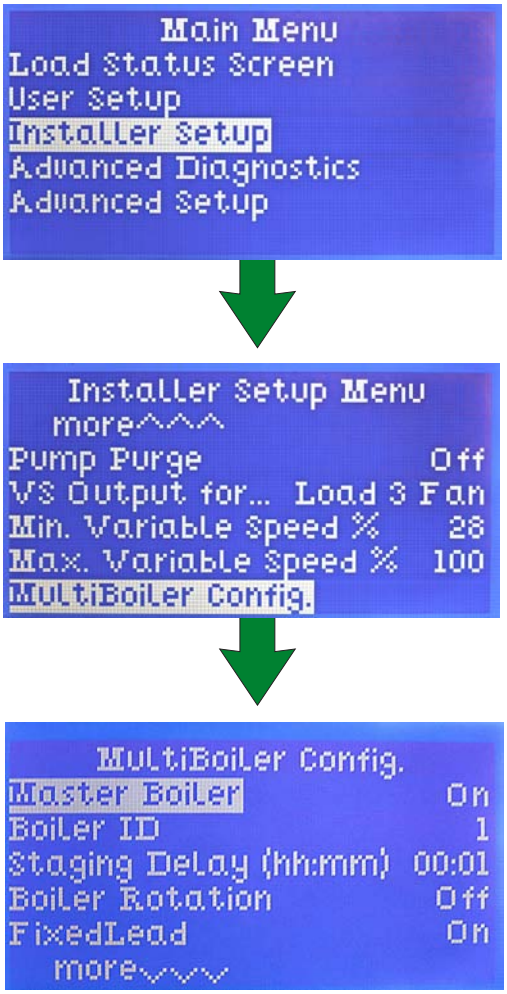
The key decision to be made is choice of the boiler staging condition – e.g. at what point does an extra boiler

need to be called up. Note: drop-off condition is internal to software algorithm – no settings required. The settable parameters are the length of time the user is willing to allow for the system to raise the system water temperature by a given amount. Default values in software as delivered: a loop temperature rise (toward Target) of 5°F or more over a 10 minute period will be treated as adequate progress without call-up of further boiler units. Account must be taken of the nature and size of the most sensitive load. If there is one large mass space heating function (an in-slab radiant floor or a commercial-scale heating / cooling loop), the default settings may be satisfactory. For large volume DHW service, this would be far too slow.

Using the keypad of the intended lead boiler, go to Installer Setup and drop to the bottom line of the screen "MultiBoiler Config.". Select this function using the centre button for "enter". The programming procedure is as follows:

1. When "Master Boiler" is highlighted, select and switch to "On" (for Master boiler only – leave all other boilers set to "Off").

2. at "Boiler ID", select and using one push of the top button, increase the default value of "0" to "1". Go to the other boilers and assign "2", "3" and "4" (up to 24 units allowed).



3. at "Staging Delay (hh:mm)", set minimum delay time before next boiler comes on line (must be at least equal to time for closed-loop water to complete one full circuit of system. For large mass systems, allow for two or more loop times.

4. "Boiler Rotation" – switch this to "on" to balance the run time on each of the boilers. There is a 48 hour maximum allowable runtime difference between boilers.

5. "Fixed Lead" – When set to "On", the Master boiler will always be the first to answer a call for heat. In the "Off" state, which ever boiler has the least run time will be the first to answer a new call for heat. Note: – This feature is over-ridden when Boiler Rotation is enabled (treated as "Off").

6. "Firing" – switch between "First On / First Off" and "First On / Last Off" options. Note: – this feature only works with modulating boilers.

7. "Fixed Fire Boiler Sel." – this pertains to applications where one or more modulating IBC boilers are grouped with on/off boilers within a single system. The lead boiler can switch up to 4 further on/off units when connected through the optional "Multi-Mix" harness and satellite module. To invoke, select then move the cursor over an asterisk and use the top button to arrive at "1". Repeat at the next asterisk for each further boiler involved. Must be set to "****" when fixed fie boilers are not controlled by the master.

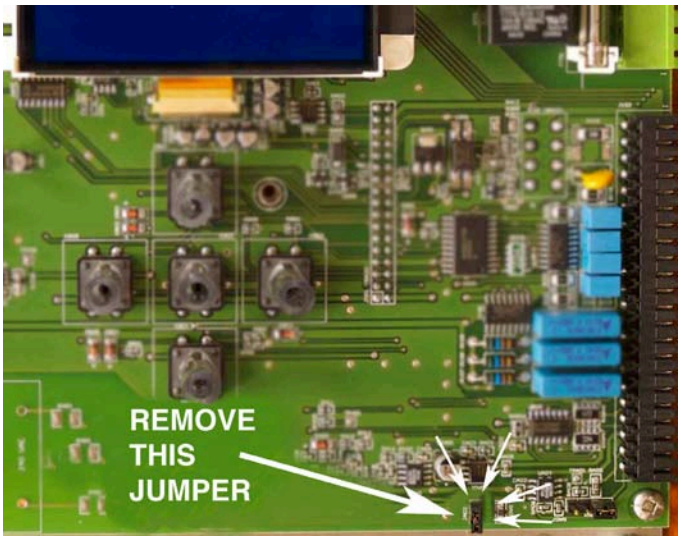
8. Setup & configure heat loads on Master boiler.

Helpful hint:

To speed up confirmation of system operation, move the Staging Delay to 00:01 minutes to witness proper operation of the call up of other units.

Jumper removal

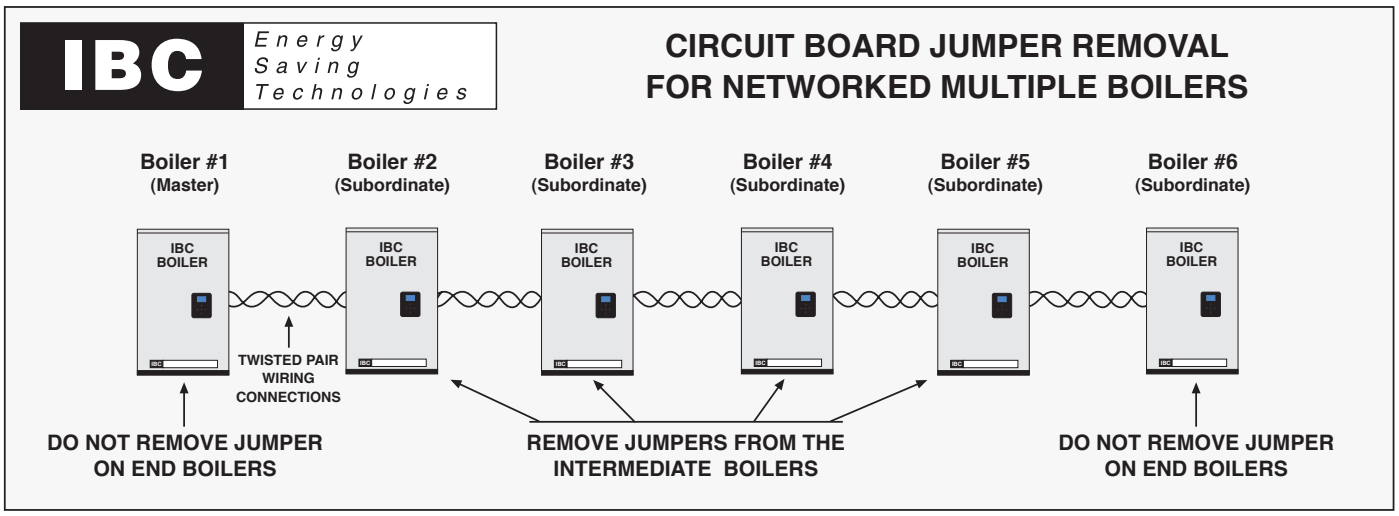
When multiples of 3 or more boilers are configured, removal of a circuit board jumper as illustrated becomes necessary. This procedure must be completed for the boilers to stage and communicate properly with each other.



1. Turn power off to the boilers.
2. Remove the control board covers from each intermediate boiler in the array.
3. Locate the jumper clips at the bottom right of the circuit board. There are two of them. The jumper on the bottom far right changes the “Ext. Cont” signal from 4-20mA (default) to 0-10VDC - do not remove
4. this jumper. The jumper for configuring multi boiler operation is the one shown in the photo above.
5. Pull this jumper clip straight away from two pins on the circuit board and store it somewhere safe in case it might be needed in the future. Common practice is to replace it so that it hangs onto the bottom pin only.
6. Replace control board covers and restore power to the boilers.

External DDC authority:

Generally DDC systems are relied upon for staging of individual boiler units. Variations – where multiples are linked to act as a virtual “single” are beyond the scope of this bulletin.



Domestic “opt-out” notes

The domestic “opt-out” option was developed to increase the overall efficiency of a boiler plant, especially when operating in buildings that spend a large part of the Summer months and shoulder season in Summer shut-down

mode. In traditional piping arrangements and control treatments, the building system pump would run continually, or a call for domestic hot water would result in the commencement of system pump operation. The boilers would subsequently fire and heat up the mains piping for the entire building, even for a short “top up” of the DHW tank - a significant waste of energy.

The domestic opt-out function allows individual indirect storage water heaters to call up a single boiler to turn on a DHW boiler pump, divert its fluid flow and heat production directly to the tank, while turning off the boiler pump that injects heat into the heating mains, therefore bypassing the system piping. This operation all but eliminates piping losses. As a further benefit, when the boiler plant is operating in heating mode, the DHW boiler(s) can “opt-out” of the heating load, allowing the rest of the boiler plant to continue the heating task uninterrupted. If opt-out boilers are in the process of making DHW when a setpoint demand or heating demand is received by the master boiler, the remaining boilers will switch over to that load leaving the opt-out boilers to continue making DHW. If a DDC system or other external control is used to operate individual boilers the DHW opt out feature is unavailable. DHW opt out is still available when external (remote) setpoint control is used.

Good design practice for an opt-out system dictates that the heat exchanger for the indirect tank be capable of transferring the full output of the boiler at high fire. This will result in fast recovery of the tank so that the boiler can return to the heating load quickly, and will allow the boiler to heat up the tank at lower delivery temperatures, enhancing condensation of flue products for maximum efficiency.

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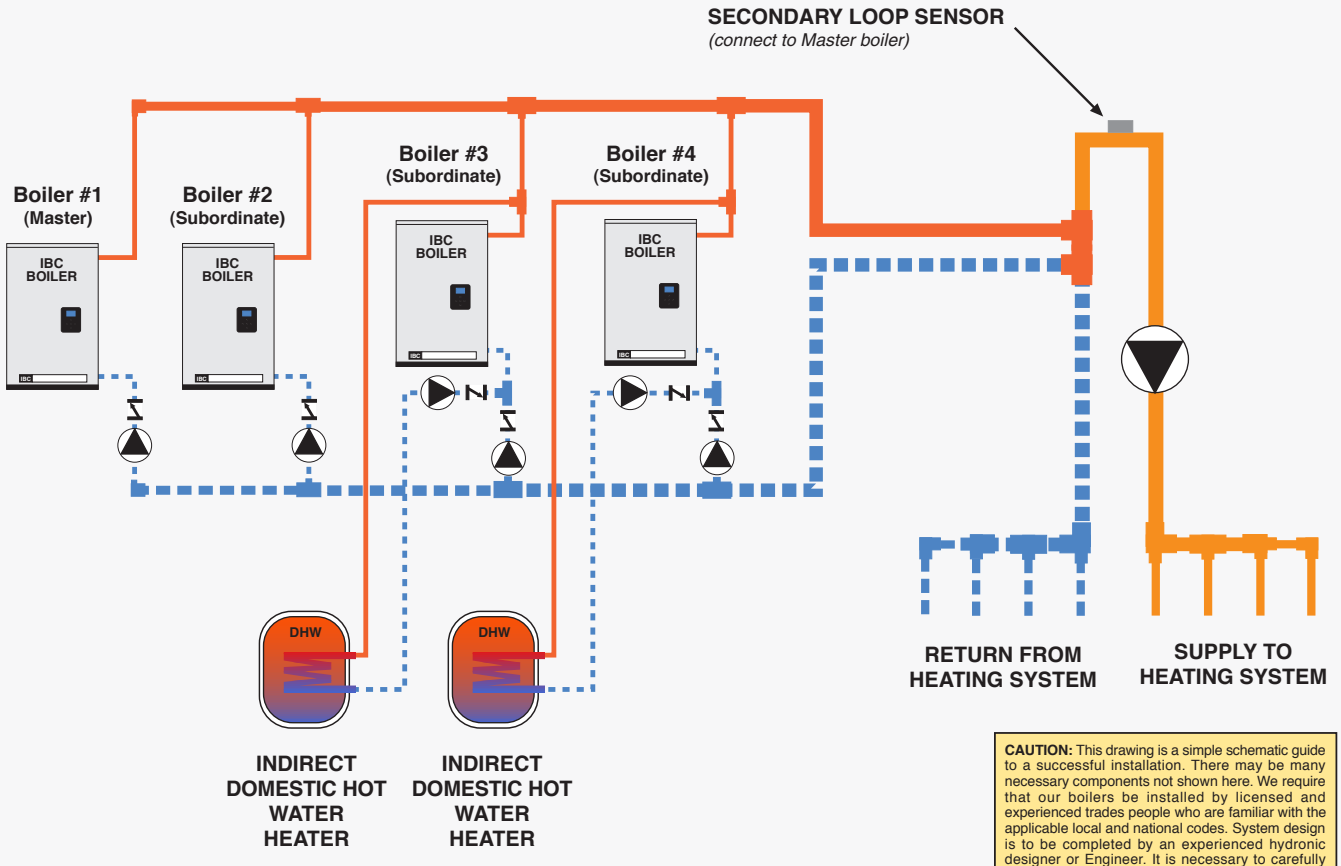
4 STAGED BOILERS WITH 2 BOILERS CONFIGURED FOR DOMESTIC HOT WATER “OPT-OUT” PRIORITY



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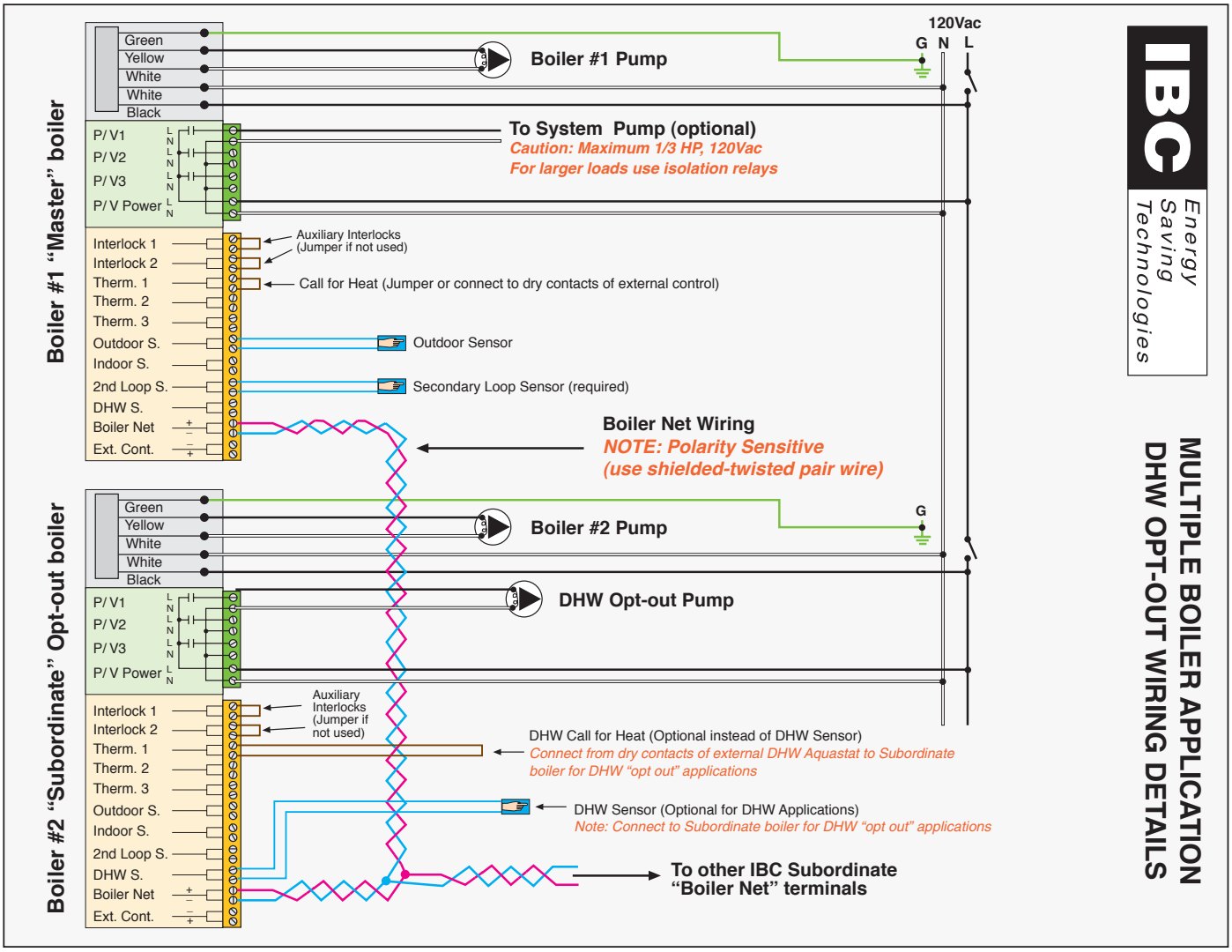

The software version is displayed briefly when the boiler is first powered up.

In the example display shown below, it is clear that this boiler would require a software upgrade before it could be used in an "opt-out" application.

Contact the factory for information on software upgrade procedures. If the boilers were not specifically ordered with Software version 2.23.1 or higher, an field upgrade will have to be performed.

DHW "opt-out" boilers cannot be configured as the Master boiler.

On set-up, "DEFINE LOAD: DHW: LOOP 2"

Either a DHW sensor or aquastat can be used to generate call for DHW for each opt-out boiler. The call for DHW goes to each opt-out boiler separately.