## PART 1 GENERAL

* 1. SUMMARY
		1. This section includes condensing hot water boiler(s) for indoor space-heating application.
	2. REFERENCES
		1. Underwriters Laboratories:
			1. UL 795: Commercial-Industrial Gas Heating Equipment.
		2. American Society of Mechanical Engineers:
			1. ASME Section IV: Boiler and Pressure Vessel Code - Heating Boilers
			2. ASME CSD-1: Controls and Safety Devices for Automatically Fired Boilers
		3. American Society of Heating, Refrigeration and Air Conditioning Engineers:
			1. ASHRAE: Standard 90.1 Energy Standard for Buildings
		4. American National Standards Institute
			1. ANSI Z21.13: Gas Fired Low Pressure Steam and Hot Water Boilers
		5. Hydronics Institute, Division of Air Conditioning, Heating and Refrigeration Institute:
			1. BTS-2000: Testing Standard to Determine Efficiency of Commercial Space Heating Boilers
		6. National Fire Protection Association:
			1. NFPA 54: National Fuel Gas Code (ANSI Z223.1).
		7. Relevant local and/or project specific Codes and Standards
	3. SUBMITTALS
		1. In accordance with Contract Documents. Minimum product data to include:
			1. Capacities, accessories and options included with boiler.
			2. General layout, dimensions, size and location of all required connections.
			3. Electrical characteristics - provide wiring diagrams that are specific to this project.
			4. Weight and mounting loads.
			5. Manufacturer's installation and start-up instructions.
			6. Equipment Operation and Maintenance Manuals and control device cut-sheets.
	4. QUALITY ASSURANCE
		1. Use an adequate number of skilled workers, trained and experienced in the necessary crafts, and who are completely familiar with the specified requirements, pertinent contract documents, and methods needed for proper performance of the work described therein.
		2. Provide the services of a manufacturer's factory-authorized representative to inspect and verify proper installation of this equipment, and to provide equipment start-up and operator training.
	5. DELIVERY, STORAGE, AND HANDLING
		1. In accordance with Contract Documents.
		2. Accept equipment and accessories in Factory shipping packaging. Inspect for damage. Keep boiler in a vertical position from time of delivery to final installation.
		3. While stored, all equipment must be protected from external elements such as inclement weather, job site construction activity, etc. Protect equipment from damage by leaving packaging in place until installation.
	6. WARRANTY
		1. The boiler shall come with the warranties stated below. Warranty period shall be one (1) year from date of start-up or eighteen (18) months from date of shipment, whichever comes first.
			1. Lifetime, shockproof warranty on seal of tube to header. Covers leaks in pressure vessel attributed to unequal expansion.
			2. All stainless steel heat exchanger shall carry a 10-year limited warranty.
			3. Pressure vessel and flue collector are covered against failure due to fireside flue gas corrosion: upper & lower pressure vessel headers shall carry a 10-year limited warranty and flexible boiler tubes & flue collector sides, top and bottom shall carry a 5-year limited warranty.
			4. Burner shall carry a 1-year limited warranty.
			5. All other parts shall carry a 1-year limited warranty.

## PART 2 PRODUCTS

* 1. ACCEPTABLE MANUFACTURERS
1. Thermal Solutions Boiler, Arctic Model ARC-[1000, 1500, 2000, 2500, 3000]. Refer to the Equipment Schedule in the Contract Drawings for the specific design and performance criteria.
2. It shall be the responsibility of the Contractor to insure that any substituted equipment is equivalent in fit, form and function to the specified equipment. The cost of any additional work caused by the substitution of equipment shall be borne by the Contractor.
3. Or approved equal.
	1. GENERAL REQUIREMENTS
4. Boiler
	1. The boiler shall be factory assembled & packaged as a complete unit and shipped on a heavy steel frame or knockdown configuration. Packaged unit shall be complete with jacket, gas manifold, burner and controls mounted and wired, as specified in this Section. The boiler shall be factory fire tested prior to shipment. Knockdown unit is fully assembled and fire tested as a package then dissembled & labeled for shipment. Boiler connections shall be limited to the water supply & return, relief valve and boiler drains, fuel input, electrical power, exhaust vent and air inlet (as specified/shown in contract documents).
	2. The boiler shall be constructed in conformance to ASME Section IV and UL 795. The boiler shall bear the ASME “H” stamp and be National Board Listed for 160 psi MAWP at 210°F. The gas train and safety controls shall conform to requirements of UL 795 and ASME CSD-1.
	3. Pressure vessel shall be constructed of 316L stainless steel non-welded flexible serpentine water tubes connected to 316L stainless steel headers. All tubes:
		1. Shall be easily removed and or replaced in field without welding or rolling and may be demonstrated upon request;
		2. Shall not require ASME “R” stamp for tube replacement; and
		3. Shall provide lifetime, shockproof seal on tube to header attributed to unequal expansion.
	4. Pressure vessel shall have a minimum heat transfer area of [1000 – 125, 1500 – 606, 2000 – 606, 2500 – 918, 3000 – 918] square feet and a waterside pressure loss no more than [Refer to Flow and Pressure Drop Table at the end of specification] feet of head at a [20°F thru 100°F] temperature difference between the supply and return water temperatures.
	5. Heat exchanger shall be capable of operating up to 100OF delta T.
	6. Boiler shall be capable of variable primary or primary/secondary piping arrangements.
	7. Boiler shall be equipped with a hinged front door for easy access to control devices, wiring connections and BMS interface cables/wires.
	8. The boiler shall be furnished with an adequate number of tappings and full size inspection openings to facilitate internal boiler inspection and cleaning.
	9. The ASME data plate shall be visible through open front door without removing boiler panels or screws.
	10. The boiler shall be complete with a 16 gauge metal jacket, steel casing, finished with a suitable heat resisting powdered coated finish. It shall be constructed on a structural steel frame and properly insulated with 1 inch thick insulation. The complete jacket shall be easily removable and reinstalled. The boiler shall incorporate individually removable jacket doors, with handles providing easy access to combustion chamber access panels. The entire tube area shall be easily accessible for fireside cleaning from one side.
	11. The boiler furnace and convection chamber shall include access door opening to allow for inspection of the interior chamber and burner assembly. The interior walls of the furnace chamber shall be lined with high temperature ceramic fiber blanket insulation.
	12. The operating sound level for the boiler shall not exceed 60 dBA
	13. Electrical input to the boiler shall be [1000 - 120v/1ph/60hz, 1500 – 208-240v/1ph/60hz, 2000 to 3000 – 208-240v/1ph/60hz or 208-240-480v/3ph/60hz]. Single-point electrical hook-up for the boiler shall be provided. Separate power wiring and control wiring is not acceptable. A dedicated electrical disconnect shall be provided by the installing contractor.
		1. Combustion System
			1. The burner shall be a metal fiber mesh burner with no moving parts capable of operating low NOx operation without additional components. The burner shall fire in a full 360-degree pattern providing uniform heat transfer. A viewing port shall be provided for visual observation of burner performance.
			2. Burner operation shall provide infinite Modulation with minimum 5:1 turn down utilizing a Variable Speed Combustion Blower and air-fuel ratio control gas valve for dependable, repeatable modulation and precise combustion control. The gas valve design shall incorporate two safety valves in a single body and include the gas pressure regulator. Dampers, linkages or a single-speed fan is not acceptable.
			3. The ignition system shall be direct spark ignition with a UV scanner.
			4. The entire ignition and firing control sequence shall be monitored by a UL approved commercial-type microprocessor based integrated flame safeguard burner control with first out fault annunciation and operating sequence and diagnostic indicator lights. The burner control shall incorporate both pre-purge and post-purge timing functions
			5. The gas train shall be UL/CSD-1 compliant with a supply gas pressure range of 4”wc - 14” wc using Natural Gas. The gas train shall consist of high and low gas pressure switches (each with manual reset), a manual shut off valve upstream of burner and downstream of last gas valve. A single main gas valve body shall perform the functions of safety shutoff, constant pressure regulation and air-fuel ratio control.
			6. The boiler electrical control circuit shall include a 120V limit string containing a low water cut off, water flow switch, high limit manual reset, blocked condensate switch, burner fuse, low gas pressure switch, high gas pressure switch, blocked vent switch, combustion air/fuel proving switch. Operating Control will use UL listed water temp. sensors (UL353) and include both a supply sensor and return sensor as standard equipment with the option of adding a remote water temp. sensor as well as an outdoor air temp. sensor that can be shared for peer to peer operation or individually installed on stand-alone boilers. CSD-1 compliant.

C. Boiler Control System

1. Scope of Supply
Boiler Control System shall provide safety interlocks and water temperature control. The control system shall be fully integrated into the boiler control cabinet and incorporate single and multiple boiler control logic, inputs, outputs and communication interfaces. The control system shall coordinate the operation of up to eight (8) fully modulating hot water boilers and circulation pumps. The control system shall simply control boiler modulation and on/off outputs based on the boiler water supply temperature and an operator-adjusted setpoint. However, using parameter menu selections, the control system shall allow the boiler to respond to remote system water temperature and outside air temperatures with domestic hot water priority (DHWP) and warm weather shut down (WWSD) or energy management system (EMS) firing rate demand, remote setpoint or remote start/stop commands. In order to support large domestic demands it shall be parameter selectable to start two boilers simultaneously in response to a DHWP demand.
2. Boiler Control
Using PID (proportional-integral-derivative) based control, the remote system water temperature shall be compared with a setpoint to establish a target boiler firing rate. If the secondary loop flow speed is greater than the primary loop flow speed, firing rate is increased in response to the decrease in secondary loop temperature. When the remote system temperature is near the boiler high limit temperature, the boiler supply sensor shall limit the maximum boiler supply temperature to prevent boiler high limit events. Alternately, using parameter menu selections, the control system shall allow the boiler to respond directly to boiler supply temperature and setpoint to establish a target boiler firing rate while remote system water temperature is used for display purposes only. Each boiler’s fuel flow control valve shall be mechanically linked to the air flow control device to assure an air rich fuel/air ratio. All the automated logic required to ensure that pre-purge, post-purge, light-off, and burner modulation shall be provided.
3. Hot Water Temperature Setpoint
When the controller is in the local control mode, the control system shall establish the setpoint based on outside air temperature and a reset function curve, or be manually adjusted by the operator. When enabled, the setpoint shall be adjusted above a preset minimum setpoint upon sensing a domestic hot water demand contact input. When in remote mode, the control system shall accept a 4-20ma or Modbus [\*OPTION: 0-10Vdc] remote setpoint or firing rate demand signal from an external EMS.
4. Multiple Boiler Sequence
The controller shall incorporate its peer-to-peer communications on each connected boiler (up to eight [8] units) by using standard RJ45 ethernet cables. The control system shall allow the connected boilers to exchange signals as required to provide coordinated fully modulating lead/lag functions. It shall not be required to wire individual control signals between boilers. Multiple boilers shall be modulated in “Unison” (all at the same firing rate). To increase operational efficiency, the control system shall utilize both water temperature and firing rate based boiler sequencing algorithms to start and stop the boilers and shall minimize the total number of boilers in operation. The control system shall start and stop boilers when the water temperature is outside the adjustable temperature limit for longer than the adjustable time delay. In order to minimize temperature deviations, the control system shall start and stop the next boiler when the “lead” boiler is at an adjustable firing rate limit for longer than the adjustable time delay. The control system shall monitor both boiler lockout and limit circuits to automatically skip over those boilers that are powered down for maintenance, tripped or otherwise will not start. The boiler shall be run at low fire for warm-up for a preset low fire hold time. When enabled, warm weather shut down control logic shall prevent boiler operation. The controller shall also be capable of auto-rotation of the boilers based on user-selected run time hours.
5. User Interface
A touch screen message display shall be provided to display real time BTU/hr, numeric data, startup and shutdown sequence status, alarm, system diagnostic, first-out messages and boiler historical information. In the event of a fault condition, the display shall provide help screens to determine the cause of the problem and corrective actions. Historical information shall include graphical trends, lockout history, boiler & circulator cycle counts and run time hours.
6. Circulator Control
The controller shall be capable of sequencing the boiler, domestic hot water or system circulators. Simple parameter selections shall allow all three pumps to respond properly to various hydronic piping arrangements including either a boiler or primary piped indirect water heater. The controller shall perform circulator exercise to help prevent pump rotor seizing.
	* + 1. EMS Communication
			Control and monitor the boiler via communication RS485 Modbus or direct wiring. The control shall allow for simultaneous communication for boiler peer-to-peer communication and EMS communication interfaces. Loss of EMS communication shall automatically transfer the boiler control to local operation. Boiler operation shall not be lost due to corrupt or loss of EMS communication. The boiler control system shall allow individual boiler limits, lockout, boiler and system temperatures and firing rate status to be readable and water setpoint, boiler firing rate, and start/stop command to be readable and writable. The control shall provide easy parameter selection and options for the following: Modulation Source (4-20ma or Modbus [\*OPTION: 0-10Vdc]); Setpoint Source (4-20ma or Modbus [\*OPTION: 0-10Vdc]); and Enable/Disable (contact wired or Modbus). The control shall allow a real time, live & convenient list of all interface signals to allow for quick interface verification. [OPTION: The boiler control system shall network with a communication gateway to connect with BACnet [LonWorks] [Johnson Controls Metasys N2] communication protocol.]

\*Note to Spec Writer: 0-10Vdc option available with EMS Signal Converter

* + - 1. External Data Transfer

The control system shall include the ability to transfer parameters from boiler to boiler. Upon completion of commissioning the first boiler, a USB flash drive shall allow settings to be “downloaded” from one boiler and “uploaded” into the next. Additionally, these files shall be able to be sent via email and “uploaded” to a remote technical support system. Additionally, it shall be possible to restore parameters to the “as shipped state” by selecting a “Factory Default” Button.

* + - 1. Archive History

All hard lockouts, soft lockouts (holds), sensor faults, Energy Management System (EMS) signal faults, sequencer faults and limit string faults shall be recorded with a time and date stamp. The time and date log shall stores up to 3000 alarm & events even after power cycle.” The alarm & event log must be downloadable to a USB thumb drive. The control shall include collect and store supply & return temperature, flame intensity and firing rate for at least 4 months. It shall be a simple matter to page through the boiler’s operation using the boiler mounted display or download the historical data to a USB thumb drive for off-site analysis. All data must be stored in standardly compatible CRV files.

* + - 1. Quality Assurance

 The boiler control system shall be supplied as part of a factory-assembled and tested burner control cabinet.

D. Water Trim

1. Water trim devices including an ASME rated pressure relief valve set at [30, 50, 60, 75, 100, 125, 150] psi, combination water pressure and temperature gauge and water flow switch & LWCO to prevent burner operation during low water flow conditions shall be provided.

E. Vent & Intake Air Connections

1. The boiler shall be designed to accommodate sealed, direct, or other positive pressure venting options. The flue duct shall be AL 29-4C or other stainless steel vent material approved for condensing flue gases for positive pressure venting. Single wall vent is acceptable where allowed by local code. Available pressure drop range to be provided for longer runs and upsizing. Common venting is allowed if sized properly to maintain a neutral to slightly negative draft. A mechanical draft system may be required
2. When used for sealed combustion, air intake piping can be PVC or galvanized smoke pipe that is sealed and pressure tight. Pipe must be at least the same size as the inlet air connection on the boiler.
3. Combustion air shall be preheated by passing around the exterior of the boiler furnace section.
4. The combined pressure drop through the vent and combustion air duct shall not exceed 100 equivalent feet.

2.3 PERFORMANCE

1. Boiler shall be AHRI certified at a minimum 95% thermal efficiency.
2. Provide services of a manufacturer's authorized representative to perform combustion test including boiler firing rate, gas flow rate, heat input, burner inlet gas pressure, percent carbon monoxide, percent oxygen, percent excess air, flue gas temperature at outlet, ambient temperature, percent combustion efficiency, and heat output. Perform testing in accordance with contract documents.

## PART 3 EXECUTION

3.1 INSTALLATION

1. In accordance with Contract Documents and boiler manufacturer's printed instructions.
2. Flush and clean the boiler upon completion of installation in accordance with manufacturer's start-up instructions. The boiler must be isolated when any cleaning or testing of system piping is being performed.
3. Install skid plumb and level, to plus or minus 1/16 inch over base.
4. Maintain manufacturer's recommended clearances around and over equipment, and as required by local Code.
5. Arrange all electrical conduit, piping, exhaust vent, and air intake with clearances for burner removal and service of all equipment.
6. Connect exhaust vent to boiler vent connection.
7. If shown in Contract Drawings, connect full sized air inlet duct to flanged connector on boiler.
8. Connect fuel piping in accordance with NFPA 54. Pipe size to be the same, or greater, than the gas train inlet connection.
9. Use full size (minimum) pipe/tubing on all gas vent connections.
10. Connect water piping, full size, to supply and return connections.
11. Install all piping accessories per the details on the contract drawings.
12. Install discharge piping from relief valves (open termination for viewing) and all drains to nearest floor drain.
13. Provide necessary water treatment to satisfy manufacturer’s specified water quality limits.

