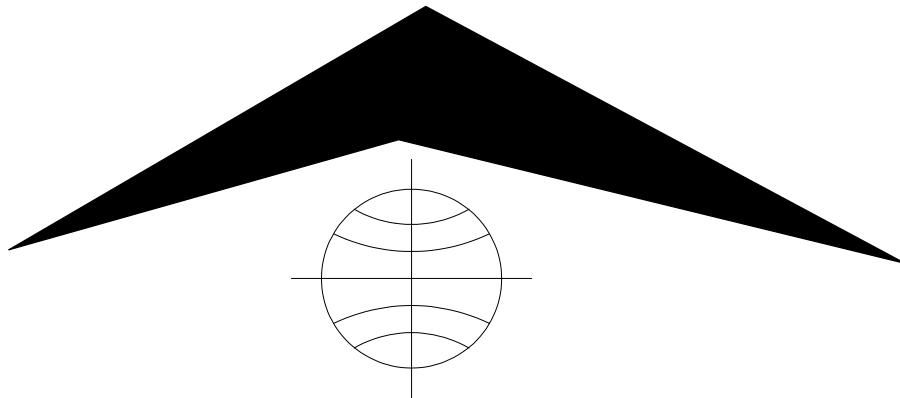


# HFP-2293 HEAT PULSE FLOW METER



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## General Information

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### Overview

The Heat Pulse Flowmeter Model HFP-2293 is a tool designed to measure low flow rates in the borehole environment. In conjunction with a low flow rate reading the HFP-2293 will also give the direction of the flow of fluid, up or down in the borehole. Operating on a MGX or MGX II with single conductor wireline and supplied software, the tool is a very useful instrument in determining low flow rates.

As mentioned above the tool is supplied with PC based software, centralizers and a range of diverters for 4 inch through 8 inch holes. Diverters are devices that divert flow in the borehole through a column where the measurement is taken by the tool. The tool can also be run in a 2 inch undeviated hole without a diverter assembly to allow for a safety factor to determine the direction of flow in the borehole. Although running the tool in a 2 inch hole without a diverter will give you a flow rate, it is an uncalibrated reading and cannot be held to the specifications mentioned in this document. Any attempt to use this tool without a diverter or a diverter of improper size with respect to the borehole may result in erroneous data.

The HFP-2293 is also supplied with a trigger assembly. The trigger is a device that communicates to the probe through the cable line, to start a heat pulse measurement cycle. The trigger can be tied into the system via the banana jacks on the MGX or MGX II.

This document describes the hardware of the HFP-2293 Heat Pulse Flowmeter, installation procedures, tool maintenance and logging procedures. There are separate documents for the operation of the different types of software depending on logger type and or firmware versions, and there will be references made in this document that will relate to the software document regarding certain logging procedures.

### Controls, Connectors, and Layout

Controls for the HFP-2293 consist of a trigger assembly that allows the user a means to communicate to the tool to begin a heat pulse measurement cycle. This trigger assembly can be thought of as a simple switch, that when pressed, instructs the tool to fire the heat grid. This trigger assembly connects to the cable line at the surface. The connection can be made on the MGX at the banana jacks or through an area in the surface equipment where access to the cable lines can be made. The trigger assembly is shipped from the factory with banana plugs as a means of termination. For the connection described above, any connector may be used that is compatible with the surface equipment.

Connectors for the tool are as follows. The probe top described below is a Mount Sopris standard single conductor probe top. Other variations of probe tops and wiring can be accommodated at the factory but will not be discussed in this document.

**PROBE TOP CONNECTOR:**

<u>Pin</u>	<u>Signal</u>	<u>Origin</u>
Probe top housing	Tool power ground	Armor
Center pin in probe top	Tool power positive	Center conductor

Connectors on the tool that are exposed to the borehole environment are located on the bulkhead assemblies. These connectors allow a pressure sealed electrical connection to be made from the inside of the tool to the outside of the tool. These connectors are used for the sensors that measure the heat pulse, and the heater grid, which heats the borehole fluid. On the bulkheads, located under or covered by the filter screens, numbers are stamped by the corresponding connectors and labeled 1, 2 and 3. The connector labels must line up with one another from the top bulkhead to the bottom bulkhead.

Their connections are as follows.

**TOP BULKHEAD:**

<u>Pin</u>	<u>Signal</u>	<u>Origin</u>
1	Signal from sensors	Top thermistor
2	Connection to heat grid	High voltage capacitors
3	For future use	

**BOTTOM BULKHEAD:**

<u>Pin</u>	<u>Signal</u>	<u>Origin</u>
1	Signal from sensors	Bottom thermistor
2	GND for sensors and grid	Armor
3	N.C.	

Layout for the tool in general is as follows starting at the bottom of the tool. The lower section consists of the measurement column, diverter, heat grid and sensors. Above the lower section is the main housing of the probe where the electronic circuits reside. Above the housing is the probe top, which is the connection to the cable head tied to the winch assembly.

**Theory of Operation**

The Heat Pulse Flowmeter operation is as follows. The tool is lowered into the borehole via a cable attached to a winch. When the tool is in position to take a flow measurement the trigger assembly button is pressed. This sends a pulse down the center conductor which when detected by circuitry in the probe, fires the heat grid and signals the surface monitoring equipment and software to begin a flow measurement cycle. The grid heats a sheet of water that moves with the flow of the borehole to the upper or lower sensor. The difference in temperature between the sensors is detected by an amplifier. The output of this amplifier is then converted to a frequency. This frequency is then driven up the cable line and monitored by the surface equipment. When the tool is pulsed by the surface, the tool immediately begins to charge the capacitors that produce the voltage for the heat grid in preparation for the next measurement cycle. A complete flow measurement is made when the time has been accurately measured from when the heat grid was fired to when a peak temperature change, carried by the flow was detected by either the sensor located above or below the heat grid.

The P.C. based software supplied with the tool is very versatile in determining the flow of the borehole. There are two types of software available for use with the HFP-2293. Depending upon the type of data acquisition software used by the MGX II system, either Mslog or Logshell, the programs MSHeat for Windows is distributed or SBCFlow for Logshell users. The MSHeat program operates under the Windows environment. The software, SBCFLOW, is ACQSBC based and users of Mount Sopris MGX LOGSHELL software will be somewhat familiar with the look of the software once they are in the data acquisition portion. A document thoroughly describing the use of the software is also supplied with the tool. This document will again depend upon the type of data acquisition the MGX II system utilizes.

**Specifications**

The tool, in order to utilize the supplied software must operate with the Mount Sopris MGX hardware and software system. This system is comprised of an MGX logger or MGX II Console connected to a logging system and operating software.

**Power Requirements**

D.C. voltage at probe top.    MIN. 30 VDC    MAX. 68 VDC    @    200mA  
Cable Armor    GND Center conductor    POWER

**Tool Output**

Pulse type, positive going, 1.25uS wide from 4.5 KHz to 37000 KHz.

**Measuring Range**

0.03 gpm to 1.0 gpm            0.113 lpm to 3.785 lpm  
0.15 ft/min. to 13 ft/min.    0.046 m/min. to 3.962 m/min.

**Resolution**

5%

**Accuracy**

5% (Mid-Range) to 15% (Extremes)

**Pressure Rating**

2000 PSI or 13789 Pascal

**Dimensions**

Length	48 inches	122 cm
Diameter	1.63 inches	4.1 cm
Weight	12 lbs	5.5 kg

**Installation**

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**Installing the HFP-2293 and support equipment**

Refer to documentation on the Data Acquisition software for proper installation onto PC.

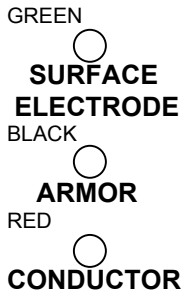
Before operating the Heat Pulse Flowmeter, a few simple steps must be performed to ensure that the equipment will function properly.

**Installing the Trigger assembly**

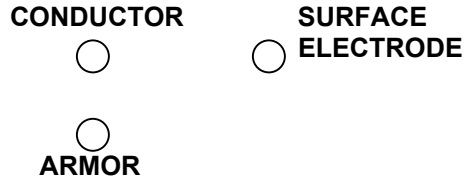
The trigger assembly provided with the HFP-2293 is a small hand held device with a push button switch in the top, a cable, about 6 ft. in length, and color-coded banana plugs on the end of this cable. The color-coded plugs or wires from these plugs must be tied into the cable lines at the surface. The MGX logging systems have these color coded banana jacks ensuring an easy installation of the trigger assembly. Remember to disconnect the trigger assembly from the logger after the use of the HFP-2293 or during the use of other types of probes. The black plug or wire connects to the banana jack labeled **ARMOR**. The red plug or wire connects to the banana jack labeled **CONDUCTOR**.

**CONNECTIONS FOR TRIGGER ON MGX**

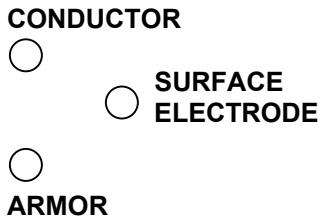
BANNANA JACKS  
ON MGX-200 and 305 units



BANNANA JACKS  
ON MGX-200 and 305 units



BANNANA JACKS  
ON MGX II Consoles



## Operating Procedure

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### Operation

Operation of the heat-pulse Flowmeter will begin by determining the size of the borehole to be logged. This is important in that the proper diverter size can be assembled on the probe to give the maximum sealing while in the borehole. Several different diverter sizes are supplied with the HFP-2293, for different sizes of hole diameters. The smallest set of diverter petals is 5 inches that are used in 3 to 4 inch borehole. The next set of diverter pedals are 7 inches and are used in 5 to 6 inch boreholes. The largest set is 9 inches and is used in 7 to 8 inch boreholes.

To install a set of diverters first remove the rings that capture the bottom centralizer using an Allen wrench set. Then remove the bottom screen by loosening the setscrews and sliding the screen off. Choose the desired size of diverter petals to be used. Next slide the stack of diverter petals over the bottom of the probe all the way to the top screen, and then reinstall the bottom screen, centralizer and centralizer rings. Tighten all setscrews. Next install the top centralizer by loosening the setscrews on the centralizer ring and slide it off the probe. If the hole is 6 inches or larger use the larger centralizer; if the hole is 5 inches down to 3 inches use the smaller top centralizer. Slide the centralizer over the top of the probe, reinstall the centralizer ring and tighten setscrews in the ring.

Install the trigger assembly into the logger, connect the probe to the cable line and prepare to log the hole. **For MGX users:** Turn the MGX PROBE SELECT switch to the Pulse 2 position; turn the PROBE POWER switch to the ON position. Bring up SBCFLOW on the P.C., and verify that the tool is sending pulses to the surface on counter CS32. If any other sequence is used besides the one previously discussed SBCFLOW will assume that it has received a fire pulse and system will be out of synchronization. **For MGX II users:** Choose the proper tool file for the M2FLOW program for Logshell or run the MSHeat program for Windows and verify that the calibrations are correct for the probe. Power the probe with the proper menu item or Windows button. The probe will take approximately 30 seconds to charge the high voltage capacitors and approximately a minute to stabilize internal circuitry. Lower the probe down the hole to the desired depth that a flow measurement will be taken. A caliper log run prior to the HFP-2293 may help indicate areas that contain washouts or fractures that will affect the sealing of the diverters. Refer to the operations manual for SBCFLOW, M2FLOW or MSHeat for more in-depth information and instructions. Make sure the software is ARMED and that the data on the screen is in a stable state. Now press the trigger button and observe the PC screen for the heat pulse peak as it passes by a sensor. For SBCFLOW and M2FLOW the waveform will go to the left of center for down flow and to the right of center for up flow. For MSHeat the data trace runs horizontal on the screen so an Up flow is indicated by the waveform moving upward from center and a Down flow moves downward from center. If no pulse is present check to see that there is an adequate pick window. If the pick window is long enough and no flow is present, move to another location and repeat the above steps.

When flow direction has been detected it has been determined through factory flow chambers and calibrations that an increase in the sealing capabilities of the diverters is achieved by positioning the diverter petals to bend into the flow. If the flow is down the borehole, then the correct positioning of the pedals would be up and this would be achieved by moving the probe down the hole. If the flow is up the borehole, the correct positioning of the petals would be down and this would be achieved by bringing the tool up the hole. It may be necessary to move the tool suddenly up or down to get the petals to reverse their direction to properly position them.

Recording of data and output plots are discussed in the all the HFP-2293 data acquisition documentation. One note that should be remembered is that the tool takes approximately 30

seconds to recharge after it has been pulsed. All acquisition software's indicate this charge time by flashing TEMPORARILY DISARMED or DISARMED at the top of the screen until the probe has had sufficient time to recharge the high voltage capacitors. This may not be as noticeable at slower flows as this amount of time is usually taken to determine and record the flow, but will be noticeable at faster flows. You may need to wait a few seconds for the probe to fully recharge.

### **Performance Checks and Calibrations**

Calibrations are performed at the factory and require an elaborate setup. In the event the user feels the tool needs to be calibrated it is advisable to speak with a representative of Mount Sopris. Performance checks can be made in and out of the borehole. When the tool is in fluid, it is good practice to verify a frequency coming from the probe and that the firing or pulse circuit is functioning correctly before continuing down the borehole. The sensors can also be checked for operation near the surface by firing the heat grid while the tool is in fluid and moving the tool up the hole simulating down flow. Repeat the firing sequence, but move the tool down the hole simulating up flow. Note that to move the tool up or down for this test, do not use the winch. Move the tool by hand to simulate flow in the borehole.

### **Preventative Maintenance**

The HFP-2293 requires little maintenance other than washing the probe off after each use. Keeping the screens and the heat grid free from debris will insure smooth operation in the field. If a high-pressure washer is used to clean the tool take care not to spray directly at or on the heat grid, as this is a delicate area. If the tool is to be stored in a horizontal position it is advisable to remove the centralizers and diverter petals so as not to deform them.

## Troubleshooting

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### Problems with the Tool

In the event the tool develops a problem, follow the troubleshooting procedure listed below.

No pulses from the probe.

1. Are the MGX switches set correctly? **PULSE 2** and **ON** positions
2. Are the PROBE CURRENT and PROBE POWER LED's on?
3. Check the cable for conductive leakage across the center conductor to ARMOR.
4. If an oscilloscope is available verify if the probe is sending pulses, if not consult Mount Sopris.
5. If using M2FLOW or MSHeat, did you power the probe up with the software?

The probe will not fire for a measurement cycle.

1. Check that the trigger assembly is connected properly.
2. If step 1 is OK, connect a voltmeter on the banana plugs while they are still plugged into the MGX and the MGX is still on as if it were powering the probe. With the probe powered on, press the trigger button and observe that the voltage on the meter: approx. 60 volts, decreases to about 10 volts or less momentarily. Not all meters will react the same to this short period, but you should see a change on any meter regardless of its reading. This is a reasonable indication the trigger assembly is operating correctly.
3. If step 2 is OK consult Mount Sopris.

The probe appears to fire or be pulsed but no flow is detected.

1. This problem may indicate a failure in the high voltage section or it may indicate that the electronics is functioning correctly, but the heat grid may be broken or open. It is important to note that a no flow detected may also occur if the tool is in a no flow zone, or if the flow is too fast. So verification of this problem is more complete if the tool is in a zone with known flow. If a zone with flow is not known or available the tool can be fired and then moved by hand either up or down to simulate flow and see that the sensor or sensors are working. If the problem cannot be determined consult Mount Sopris.

### Disassembly Instructions

The HFP-2293 probe should never be disassembled unless service is necessary. In the event service is necessary it should be performed by Mount Sopris or a qualified technician.

**Schematics**

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HFP-2293

Available upon request

Drawing Number 50002015A.S01 - S02

Title: Firing Cir. Signal Amp, V/F and H.V. Reg.  
Trig., Pulse driver and Power supplies

Drawing Number 50002029A.S01

Title: Trigger HFP-2293

## Appendix

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### Suggested QA Procedure

General notes for Quality Assurance are presented here for users who need to utilize these techniques when collecting data. These users will need to periodically calibrate their equipment using equipment whose calibration is traceable to an approved standard. Details of these calibrations must be recorded.

When an instrument is calibrated, records need to be kept regarding the calibration standard(s) used and what was changed on the instrument to calibrate it. Typically, the corrections made to the instrument involve changing constants that are used to scale the raw instrument reading so that the proper value is reported. The constants must be recorded during a calibration procedure. The Mt. Sopris acquisition software provides records of the calibration constants. This aids the QA process, but does not replace the need for recording these constants at the time of calibration. The reason for this is that the length of time since the last calibration is unknown with only this information.

The device providing the standard must be traceable to an accepted standard. Examples of organizations providing standards for measuring instrumentation are: The U. S. National Bureau of Standards; The American Petroleum Institute; and the American Society for Testing Materials. For example, if the voltmeter or the density standard used for calibration is not traceable to an approved organization, such as those listed above, the calibration should not be considered valid. Records should be kept indicating the last time that standard being used for calibration was calibrated or checked against an approved standard. The QA procedure necessary for some programs mandate that the calibration standards be periodically checked against a standard approved by a proper agency.

A QA procedure may dictate that data taken from a given locale be associated with records indicating the exact time and location that the data was collected. The data itself may have to be collected in a certain format to meet requirements. Often, QA procedure specifies that surveys must be repeated and the data from the successive surveys compared. This technique is used to eliminate poor or invalid data.