HFP-2293
HEAT PULSE FLOW METER

Mount Sopris Instrument Co., Inc.
Denver, CO U. S. A.
March 19, 2013

Table of Contents

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 II or Matrix 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 Microsoft Windows based software, centralizers and a range of diverters for 4 inch through 8 inch holes. Diverters are devises 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.banana jacks on the MGX II. This trigger is not used with the Matrix and MatrixHeat where the tool is fired from within the program.

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

For the MGX II 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 II 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.

For the Matrix a trigger button within MatrixHeat software "fires" the tool to begin a heat pulse measurement cycle

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:

Pin	Signal	Origin
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:

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

BOTTOM BULKHEAD:

Pin	Signal	Origin
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 or software 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. An amplifier detects the difference in temperature between the sensors. 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, as described above, 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 either the sensor located above or below the heat grid detected a peak temperature change, carried by the flow.

Software

The Windows based software supplied with the tool is very versatile in determining the flow of the borehole. For the MGX II Logger, MSHeat software is available for use with the HFP-2293. A document thoroughly describing the use of the software is also supplied with the tool.

Note: MSHeat acquisition screen will not display properly on Windows 7 or Windows 8 and you will not be able to see the logging data.

For the Matrix Logger the software provided is MatrixHeat.exe. For MatrixHeat to operate properly Matrix or LoggerSuite software must be first installed on the PC with the Matrix USB driver.

Note: To use MatrixHeat with Windows 7 or Windows 8 you will need version 3.2.67 or later which will require that you are running the Matrix Logger with LoggerSuite (Logger version 11 or greater).

Specifications

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

Power Requirements

D.C. voltage at probe top: Min. 30 VDC Max. 68 VDC
Current Max. 200mA (while charging)

Connections

Cable Armor GND
Center conductor POWER

Tool Output Pulse type, positive going 1.25 µS wide from 4.5 KHz to 37,000 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.

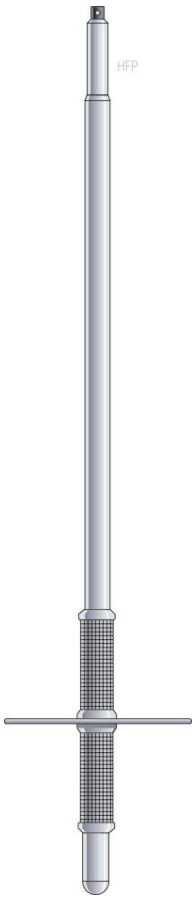
Resolution 5%

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
Cage diameter	2.1 inches	5.33 cm
Weight	12 lbs	5.5 kg



Installation

Installing the HFP-2293 and support equipment

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

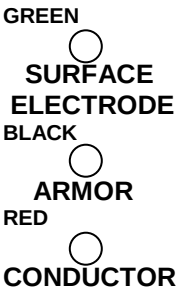
Before operating the Heat Pulse Flowmeter, a few simple steps must be performed to ensure that the equipment will function properly.

Installing the Trigger assembly on the MGX II

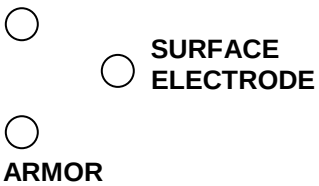
The trigger assembly provided with the HFP-2293 is a small hand held device with a push button switch in the top, a cable, about 6 ft. in length, and color-coded banana plugs on the end of this cable. The color-coded plugs or wires from these plugs must be tied into the cable lines at the surface. The 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 II

BANNANA JACKS ON MGXII 200m and 305m side mount units



BANNANA JACKS
ON MGX II Consoles



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 borehole 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.

For larger sized boreholes some large plastic disk, such as from a plastic trash can, may be used by attaching diverter petal segmants to the edges to make a flexible plug.

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.

For lage boreholes you may need to make oversized diverters from thin, plastic disks with petals from the smaller diverters stapled or riveted to the edges. Plastic Trash Can lids have been modified for this purpose.

Sealing the tool in the well

Sealing the probe in the borehole is necessary to achieve an accurate flow determination. This 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.

To flip the petals from the up direction to the down direction tug sharply up on the tool and lower it slightly to expand the petals against the borehole then secure the wireline, without lessening the tension on the probe, with the winch controls.

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.

Matrix

Connect the probe to the cable line and prepare to log the hole. Start **MatrixHea**t and select **F**ile, **A**cquire and select the Tol file. Turn the Tool power **On**. When the tool has charged, **Fire** the tool and press the **Add** button so the waveform appears in the upper panel. Select **Edit** on the top task bar, and then select **Flow Calibration** and change calibration values as necessary. Lower the probe in the hole to the desired depth that a flow measurement will be taken and seal it against the wall as described above. See the MatrixHeat Operators manual for more details.

MGX II

Install the trigger assembly into the logger, connect the probe to the cable line and prepare to log the hole. Choose the proper tool file 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 and seal it against the wall as described above.

Refer to the operations manual for 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. 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 preceding steps.

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 borehole simulating down flow. Repeat the firing sequence, but move the tool down the borehole 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.

To check basic functionality the tool can be placed in a bucket of water deep enough to cover the filter screen assemblies and allowed to stabilize. The response should be a quiet, steady trace reading about 18,000 cps across the acquisition screen. Perform this test out of strong air drafts that might cause water temperature to fluctuate.

If the water in the bucket is deep enough, fire the tool and pull it slowly and steadily up into the heated water, if done properly the software should register down flow. This takes some practice to move the tool at the proper rate to intercept the water heated by firing the tool.

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.

Replaceable parts

Diverters and centralizers

In the image above, from left to right are the following parts:

- 2DPA-1030 Lg HFP diverter (9” diameter)
- 2CNA-2030, 8” centralizer petals
- 2DPA-1020 Md HFP diverter (7” diameter)
- 2CNA-2020, 6” centralizer petals
- 2DPA-1010 Sm HFP diverter (5” diameter)
- 2CNA-2010, 4” centralizer petals
- 02000-1472, CENTRALIZER RING, HFP
- 54-901-911 2.5mm Allen wrench
- 28-176-018, SCREW, SSS M5-.8 X 6 (for centralizer,rings; not shown)

Troubleshooting

Problems with the Tool

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

No pulses from the probe.
Check the cable for conductive leakage across the center conductor to ARMOR.
If an oscilloscope is available verify if the probe is sending pulses, if not consult Mount Sopris.
If using 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. This switch is used on the MGX II but not the Matrix.
2. If step 1 is OK, connect a voltmeter on the banana plugs while they are still plugged in and with the MGX II still on as if it were powering the probe. With the probe power 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 respond 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.
For the Matrix connect the meter to the end of the cable head between the center conductor and body (armor) of the cablehead.
With MatrixHeat running and acquisition
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 to 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 Mount Sopris or a qualified technician should perform it.

Schematics

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

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.