Waukesha CFR F1/F2
Octane Rating Engine
With XCP Technology

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The Waukesha CFR F1/F2 Octane Rating Unit is the globally accepted standard for determining and certifying the anti-knock characteristics of motor fuels – whether gasoline, fuel constituents, or alternative fuels. Since the release of the first CFR unit in 1929, Waukesha CFR has been at the forefront of establishing test methods for rating fuels. Working hand-in-hand with the automotive and petroleum industries, we continue to enhance the CFR product line to help fuel producers and engine manufacturers develop products that perform together more effectively.

The CFR F1/F2 is the specified equipment for testing fuels according to:

- **ASTM D2699**: Standard Test Method for Research Octane Number of Spark-Ignition Engine Fuel
- **ASTM D2700**: Standard Test Method for Motor Octane Number of Spark-Ignition Engine Fuel
- **IP 236**: Determination of Knock Characteristics of Motor and Aviation Fuels - Motor Method
- **IP 237**: Determination of Knock Characteristics of Motor Fuels - Research Method
- **EN ISO 5164**: Determination of Knock Characteristics of Motor Fuels - Research Method
- **EN ISO 5163**: Determination of Knock Characteristics of Motor and Aviation Fuels - Motor Method
Trusted Design, Reliable Results

The core design around which the CFR engine is built has been tested and proven through rigorous and continued usage by customers around the world over many decades. Even as automotive designs have changed and fuel performance has improved, the CFR F1/F2 continues to be the gold standard for determining the octane number of liquid spark-ignition engine fuels.

Variable Compression Ratio Cylinder
At the heart of the CFR engine lies the variable compression cylinder and sleeve assembly. Varying the compression ratio by adjusting the cylinder height during engine operation makes it possible to compare unknown fuels to reference fuels with known octane values. Cylinder height is correlated to a compression ratio that can then be directly correlated to a specific octane value as per ASTM method specifications.

Four-Bowl Falling Level Carburetor
The CFR F1/F2 Octane Rating Unit is equipped with a four-bowl, variable-level carburetor that includes a falling level mode. With the falling level mode, the CFR carburetor now gives the operator the flexibility to utilize any of the four test procedures in ASTM Methods D2699 and D2700.

CFR Crankcase
The CFR crankcase is a heavy-duty cast design that provides both strength and rigidity for the loads produced by various types of fuels, and will provide long service life when operated and maintained properly. Removable side doors allow for easy access to critical internal components for inspection, maintenance, and repair.

Exhaust Surge Tank System
The F1/F2 is equipped with a surge or expansion tank that eliminates the resonant pulsations and back pressure that occur in the CFR rating unit’s exhaust lines during operation. Eliminating these variables in the testing process ensures consistent and accurate octane ratings.
XCP Digital Control Panel

**Easy-to-Use Panel Interface**
The Windows-based touchscreen provides an intuitive, easy-to-use interface. An easy-to-follow template guides new users through the fuel rating process while reducing operator interaction with the equipment. Clear graphics, color-coded indicators, and built-in prompts simplify the fuel rating process and reduce the likelihood of operator error. The simplicity of the interface enables new users to be easily and quickly trained on how to operate the engine and conduct fuel tests. Standard features include on-screen operation, on-screen reports, automated data recording, an integrated maintenance log, and network connectivity. The touchscreen is fuel resistant.

**Automated Data Recording**
With the XCP Digital Control Panel, critical information for each rating is automatically captured and presented in an Excel-based report, minimizing recording and calculating errors. Fuel rating reports include KI values, octane numbers, environmental data (temperatures and pressures), and KI vs fuel level curves. The XCP is also capable of being integrated into a Laboratory Information Management System (LIMS).

**Automated Digital Knock Meter**
The digital knock meter presents all information on a single display, while automatically recording data, calculating results, and generating reports. This software solution eliminates the need to center on 50 Knock Intensity (KI) and to be constrained by 0 - 100 KI. The digital meter also eliminates the need to set “SPREAD”, thereby allowing users to run with default settings – a huge time saver and a significant factor in reducing variability among operators.

**Electronic Barometer**
The on-board electronic barometer allows operators to easily set the required ASTM/IP method correction factor for barometric pressure without the need to reference an external barometer.

**Cylinder Height Laser Sensor**
A non-contact laser sensor provides highly accurate measurements of the cylinder height, and displays the results on-screen in dual dimension values. These values are also recorded in the test reports.

**Falling Level Program**
When the four-bowl, variable-level carburetor is used with the XCP’s falling level program, the operator can efficiently perform an accurate falling level test that determines maximum knock intensity without any manual adjustment of the carburetor bowls. This enables a single operator to run very accurate tests without the need to manipulate each bowl’s levels to determine maximum knock.
• Visual Knock Meter clearly indicates to the operator the current value of engine knock
• Knock vs time graph shows any changes in the knock trend
• Set intake air temperature or mixture temperature
• View basic engine parameters
• View error codes and status messages
• Intuitive fuel rating set up tab:
  - Choose operator and fuel name from dropdown menus, or easily add new names
  - Select any octane rating procedure
  - Set sight glass minimum and maximum levels, as well as the fuel flow rate

Fuel rating tabs on the main operating screen:

*Image to the left*
• Automatic recording of data
• KI vs fuel level chart that is updated in real time helps operators easily determine when maximum knock is achieved
• “Next Fuel” function enables operators running the falling level procedure to move on to the next fuel/air sweep once maximum knock has been achieved, without having to finish the entire min/max range on the sight glass for the current fuel
• Software will prompt the operator which specific fuel should be run next (unknown, high, low)

*Image above*
• View all data from rating in progress
• All environmental data (temperatures and pressures) are also recorded for each fuel/air sweep
• Data is time-stamped
Octane Estimator tool:

- Enables operators to perform quick estimations for fuel ratings of unknown samples
- A full fuel/air sweep is run on the unknown sample; then, using existing KI and bracket information, an estimated octane number for the unknown sample can be calculated
- Operators are then able to determine the brackets to be used to rate the unknown sample
- Max KI of the unknown sample does not have to fall between the KIs of the bracket fuels in order to get an estimate
- Note: Data from the Octane Estimator is not recorded in the data logs.

Reports:

The XCP Octane Rating Report records:
- Environmental data (temperatures, pressures, barometer)
- Timestamps
- KI values
- Octane number
- KI vs sight glass level curve

Auxiliary screens allow the operator to set basic parameters (intake air/mixture/oil temperatures), turn on the oil heater, view engine operating time, monitor real-time environmental conditions, and perform a variety of other tasks.
Model: CFR F1/F2 Octane Rating Unit
Test methods: ASTM D2699, ASTM D2700, IP 236, IP 237, EN ISO 5164, EN ISO 5163
Octane number range: 40-120

The base configuration for a standard CFR F1/F2 engine comes with the following:

- XCP panel with touchscreen PC
- Electronic barometer
- Laser sensor for measuring cylinder height
- Compression ratio change motor
- CFR48 crankcase
- Three-phase reluctance-type synchronous motor (50 / 60Hz; 220 / 380 / 440V)
- Instrumentation panel (120V, 50 / 60Hz, 1P)
- Four-bowl “falling level” carburetor with one water-cooled bowl
- Exhaust manifold (non-cooled)
- Exhaust surge tank system
- Ice tower assembly
- Desk

Options:

- KVA transformer
- Water-cooled exhaust system to provide constant cooling
- Refrigeration unit to condition intake air

Dimensions & weight:

- Approximately 1.58 x 1.49 x 0.96m (H x W x D), 909kg; (62 x 58 ½ x 37 ⅞ in, 2000lbs)
- Including concrete base: approximate height 1.96m (77in), weight 1818kg (4000lbs)
- With exhaust surge tank: approximate depth 1.4m (55 ⅛ in)

Operating Conditions:

<table>
<thead>
<tr>
<th></th>
<th>Motor Method (ASTM D2700)</th>
<th>Research Method (ASTM D2699)</th>
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<tbody>
<tr>
<td>RPM</td>
<td>900 +/- 1%</td>
<td>600 +/- 1%</td>
</tr>
<tr>
<td>Timing</td>
<td>Variable based on cylinder height</td>
<td>13° BTDC</td>
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<tr>
<td>Water jacket temperature</td>
<td>212°F +/- 3°F</td>
<td>212°F +/- 3°F</td>
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<tr>
<td>Oil temperature</td>
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<tr>
<td>Oil pressure</td>
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<td>25-30psi</td>
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<tr>
<td>Vacuum</td>
<td>1-6 inH₂O</td>
<td>1-6 inH₂O</td>
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<tr>
<td>Intake temperature</td>
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<td>100°F +/- 5°F</td>
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<tr>
<td>Mixture temperature</td>
<td>300°F +25°F / -15°F</td>
<td>N/A</td>
</tr>
<tr>
<td>Intake humidity</td>
<td>25-50 grains H₂O / lb dry air</td>
<td>25-50 grains H₂O / lb dry air</td>
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