Waukesha DRESSER

CFR

CFR fuel testing committee, circa 1932, with early CFR engine.

CFR PRODUCT LINE
Historical Overview

Waukesha Engine Division has been designing and producing fuel-rating test equipment since 1931. Our five units are recognized worldwide for producing consistent, accurate test results in determining the combustion characteristics of motor and aviation gasolines and diesel fuels:

- **CFR F-1 Research Method Octane Rating Unit**
  conforms to ASTM D 2699 and ISO-5164
- **CFR F-2 Motor Method Octane Rating Unit**
  conforms to ASTM D 2700 and ISO-5163
- **CFR F-2U Combination Research/Motor Method Octane Rating Unit**
  conforms to ASTM D 2699 (ISO-5164) and ASTM D 2700 (ISO-5163)
- **CFR F-4 Supercharge Method Aviation Gasoline Rating Unit**
  conforms to ASTM D 909 and IP Method 119
- **CFR F-5 Cetane Method Diesel Fuel Rating Unit**
  conforms to ASTM D 613 and ISO-5165

Since the very beginning, our equipment has been designed to correspond to test methods written by ASTM (and its predecessor organization). These methods represent an ongoing cooperative effort from the petroleum and automotive industries, and government regulatory agencies. Changes in Waukesha Engine Division equipment and instrumentation are always made with the consensus of the fuel-rating community in order to ensure consistency with historical test results.

Early Testing Initiatives

Development of a system to measure the knock characteristics of fuels evolved from the general recognition that engine performance is affected by the compression ratio and a fuel's anti-knock properties, as taught by Ricardo.

A far-sighted group of fuel producers and engine manufacturers formed the Cooperative Fuel Research (CFR) Committee in 1922 to explore areas of common interest. Six years later, the committee saw the need to establish engine test methods for rating fuels. Initially, the focus was on developing a test method and equipment for motor gasoline knock rating. The task was assigned to a group of petroleum and engine technologists designated as the Detonation Subcommittee.

By 1931 a standardized engine, specific reference fuels, a rating scale and a uniform testing procedure became realities. Waukesha Motor Company (now the Waukesha Engine Division of Dresser Industries) was the key contributor in the engine development area and began producing a single-cylinder, variable compression ratio test engine which took the name "CFR Engine," having been approved by the CFR Committee.

Isooctane and n-heptane were adopted as the reference fuels, and the 0 to 100 octane scale was defined. Road-testing of automobile fuels occurred between 1932-34, leading to the acceptance of the Research and Motor Methods of testing fuels for automobiles. The Research Method (ASTM D 2699) tests fuels at 600 RPM and the Motor Method (ASTM D 2700) conducts testing at 900 RPM.

Diesel and Aviation Fuels

The next challenge was to develop a system for rating diesel fuel. The industry agreed on using cetane as the reference fuel for testing. The basic CFR engine had to be modified because ignition delay was the method chosen to test the combustion properties of diesel fuel. The Cetane Method (ASTM D 613) was adopted in 1938.

A system to rate aviation fuel emerged during World War II as a U.S. military initiative. The Supercharge Method was approved in 1940, but was re-evaluated between 1947-52 so that fuels for both cruise-type performance and maximum power with rich fuel air ratio performance could be rated using a single procedure (ASTM D 909). However, the non-supercharged Motor Method is now ordinarily used as an index of the fuel's knock characteristics under lean cruise conditions.

Quality and Consistency

CFR testing units have been in use since 1931. Operators of the equipment have come to rely on the accuracy of the test results, which has made CFR the worldwide standard. Operators also have the assurance that the test method results are reassessed annually by ASTM to maintain consistency.

Consistency also is an important factor in the production process. Waukesha Engine Division is the only company that has ever produced the CFR test equipment. By retaining a consistent staff of dedicated engineers, managers and technicians, Waukesha Engine Division is widely known and respected in the fuel-rating community.

When it comes to evaluating the quality of a product, time is often the best test. As a result of thoughtful design and careful attention to manufacturing, Waukesha Engine has successfully demonstrated it's ability to be the world leader in fuel rating equipment.

Repair Service

Waukesha Engine Division offers specialized factory repair service for CFR equipment. All repaired equipment and instrumentation is inspected by qualified production inspectors, and then tested before shipment.

Routine repair service is available for the following CFR equipment components:

- Compression Ratio Motor
- Cylinder Rebuilding
- Connecting Rods
- Crankcase Rebuilding
- Temperature Controllers
- Detonation Meters
- Detonation Pickups
- Cetane Combustion Pickups

Call (414) 549-2914 to obtain a return authorization before shipping your component for repair. This number can also be used for questions concerning repairs of CFR equipment not listed above.

Service & Training Support

Waukesha Engine Division and our worldwide network of contract CFR equipment distributors are prepared to offer complete installation, service and training at your location.

The knowledge and professionalism of our field force reflects a heritage of serving the fuel-rating industry for more than 60 years.

For information on price, scheduling or to make an appointment, call our CFR Department at (414) 549-2858.

Ordering Information

Inquiries for CFR equipment can be sent to Waukesha Engine Division by mail, fax or phone (see below).

Should your country be served by a contract distributor; contact Waukesha for location information.

The following suggestions will help you request and receive the most appropriate information:

- Always identify the test method that the equipment will be used to perform.
- Specify the three-phase and single-phase voltages (50 or 60Hz) available at the installation facility.
- For safety reasons, high voltages are not permissible in the control panel. Therefore, the manifold and oil heaters will be supplied for 115 VAC only. If a step-down transformer is required, it can be supplied with the equipment at additional cost.

Orders may be sent either by mail or fax.

CFR Department
Waukesha Engine Division
1000 W. St. Paul Ave.
Waukesha, WI 53188

Phone: (414) 549-2928
Fax: (414) 549-2960

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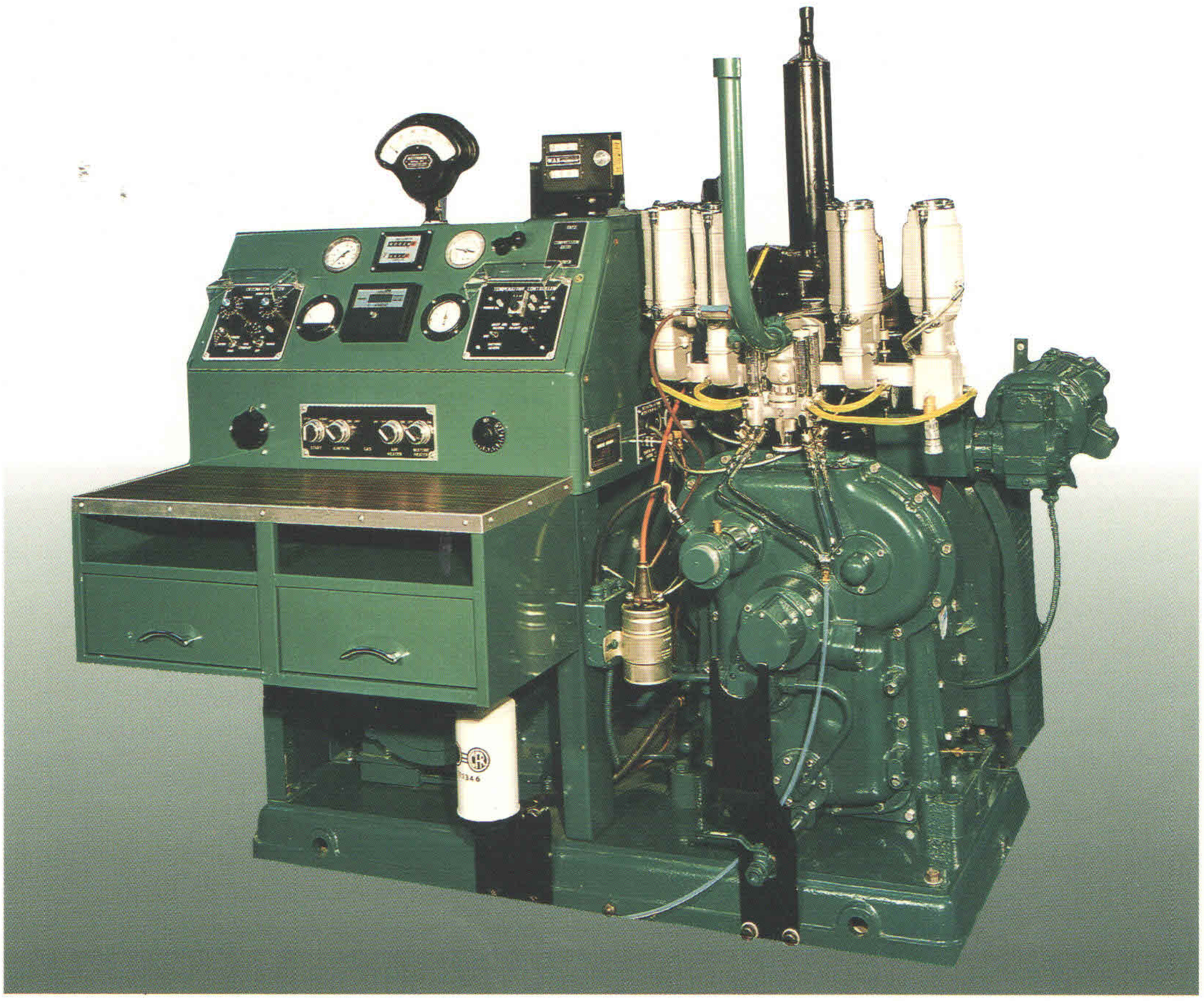


CFR F-1
Research Method Octane Rating Unit

*W*aukesha Engine Division offers a complete system for octane determination, conforming to ASTM D 2699: Standard Test Method for Knock Characteristics of Motor Fuels by the Research Method (also ISO 5164). This method is accepted worldwide as the standard for determining the octane quality of gasoline and fuel blending components.

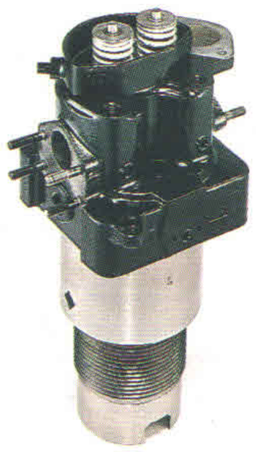
Our single cylinder CFR F-1 Research Method Octane Rating Unit (CFR F-1) produces test results under these operating conditions: 600 RPM, 212°F jacket temperature, 135°F oil temperature, adjustable intake air temperature, and spark advance set at 13 degrees BTDC. Dimensions (approx.): 55"H x 60"L x 39"W

The CFR F-1 is nearly identical to our CFR F-2 model, which produces test results by the Motor Method (ASTM D 2700 and ISO 5163) for more severe engine conditions. A combination Motor and Research unit is also available which provides the capability to switch between the two methods with only minor equipment adjustments.

No product is complete without proper parts, service and training support. Waukesha Engine provides the very best aftermarket support through a worldwide distributor network offering service and installation assistance, classroom and field training, and a global network of parts supply.

Because the Waukesha CFR Engine is the only fuel rating unit approved by ASTM, it must meet demanding quality standards prior to shipment. When you specify a Waukesha CFR fuel rating unit, you can be assured of receiving an industry standard you can depend on.

Key Design Features

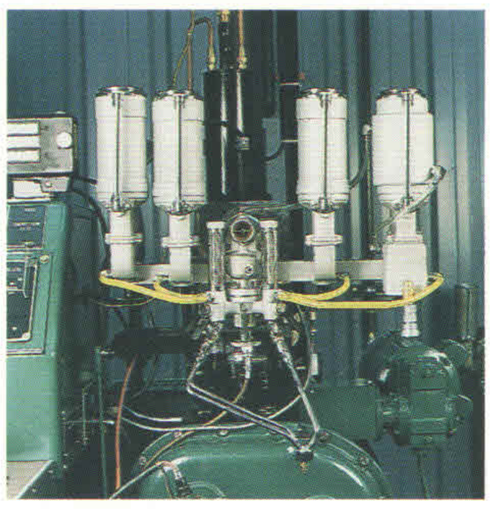


Variable Compression Cylinder

A variable compression cylinder allows the compression ratio to be changed during engine operation. The available range is 4:1 to 18:1, which allows testing a wide range of fuels. A special overhead valve mechanism provides constant valve clearance as the compression ratio is adjusted. The integral head design provides for improved reliability as well as accuracy of results.

Crankcase

The CFR-48D crankcase combines durability with simplicity of design. All CFR engines use the same cast-iron, box-type crankcase, which features removable side doors and gear cover for easy measurement and repair of critical internal components.



Carburetor

Fuel/air ratios are easily adjusted with this single-venturi carburetor by varying the fuel level. The fuel level is always visible to the operator for easy reference and recording. The carburetor is available in multiple jet and venturi sizes for all applications. Both three-bowl and four-bowl models are offered, as well as various carburetor cooling options.

Knock Measurement Equipment

A factory-calibrated, 115 VAC (50 or 60 Hz) detonation meter converts changes in combustion knock to an analog signal (with knock intensity displayed on a scale of 0 to 100). The electronic equipment is cabinet-mounted in the instrument panel and connected to a magnetostrictive pickup element mounted directly in the cylinder's combustion chamber.

Other Important Features

- **Safety systems** provide engine shutdown when any of these conditions are experienced: electrical power loss, low oil pressure, loss of cooling water, or electrical overload of the synchronous/reluctance motor.

- **Jacket coolant condenser** is of the thermal-syphon, ebullient, recirculating cylinder jacket type. While very simple in design it maintains constant cylinder water jacket temperature for stable operation.

- **Synchronous/reluctance motor** of three-phase design provides power for starting and absorbs the engine's output to maintain constant speed during operation.

- **Air humidity control equipment** is supplied to condition the engine's intake air to between 25-50 grains of moisture per pound of dry air as prescribed in the ASTM method.

- **Pressure lubrication** is used to lubricate all bearings and critical moving parts. External oil pump permits access to the main oil supply line for filtering, cooling or flow measurement.

- **Electronic ignition system** is a condenser-discharge type with coil and distributor. The adjustable spark timing is factory set at 13 degrees BTDC.

Equipment Options for the CFR F-1 Unit

Variable Voltage and Cycles	50 Hz or 60 Hz models are available to suit local requirements. The synchronous/reluctance motor is available in many three-phase voltages.
Motorized Compression Ratio Changer	A touch of the lever controls cylinder height, eliminating manual hand-crank height adjustment.
KVA Transformer	Converts 190, 200, 208 or 220 volts to 110 VAC (50 Hz or 60 Hz). Another option converts 240 volts to 120 VAC (50 Hz or 60 Hz).
Exhaust	Water-cooled exhaust provides constant cooling.
Carburetor	See photo caption for available options.

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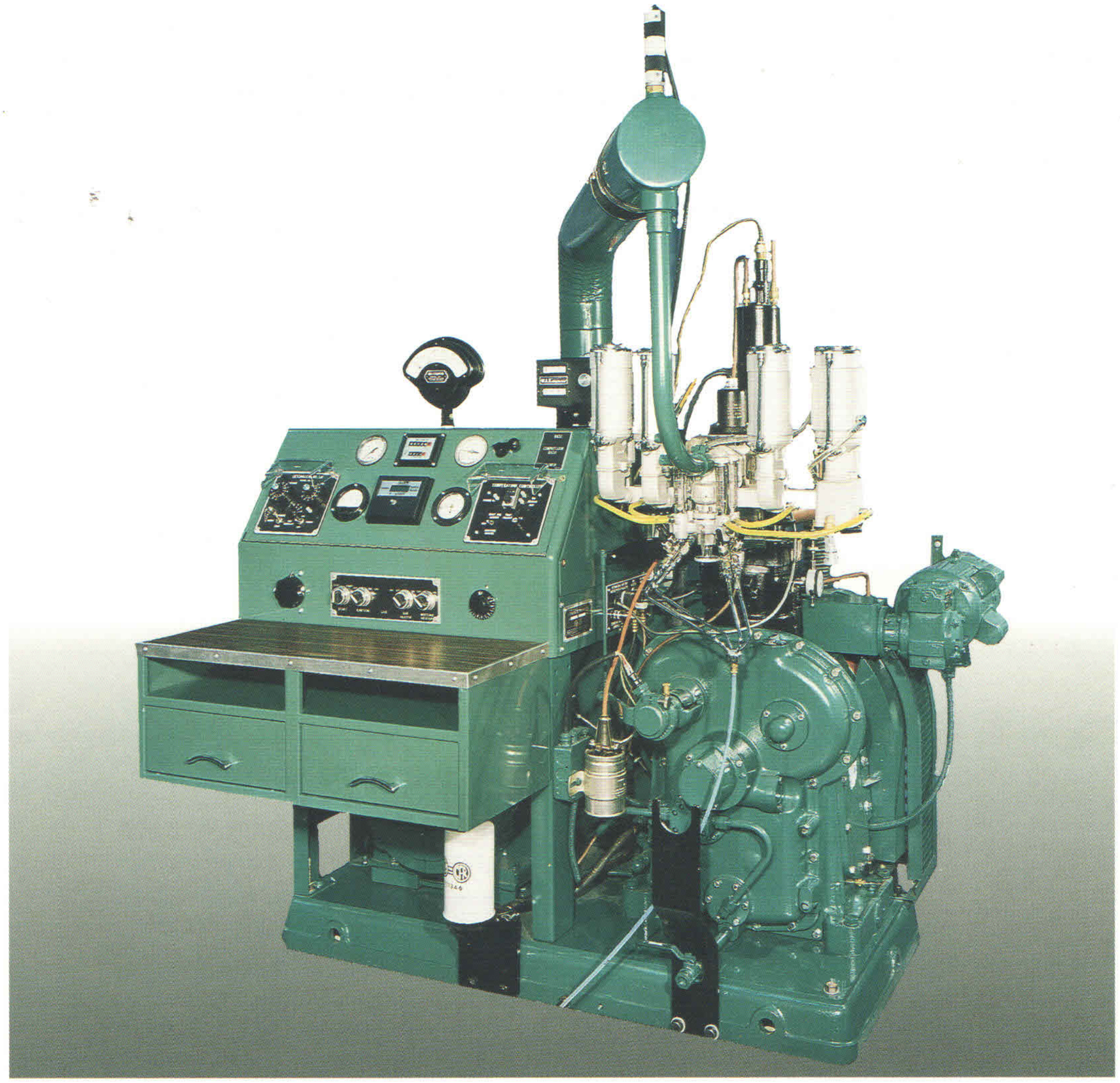
CFR



CFR F-2
Motor Method Octane Rating Unit

Waukesha Engine Division offers a complete system for octane determination, conforming to ASTM D 2700: Standard Test Method for Knock Characteristics of Motor and Aviation Fuels by the Motor Method (also ISO 5163). This method is accepted worldwide as the standard for determining the octane quality of gasoline and fuel blending components.

Our single cylinder CFR F-2 Motor Method Octane Rating Unit (CFR F-2) produces test results under these operating conditions: 900 RPM, 212°F jacket temperature, 135°F oil temperature, 300°F mixture temperature, and spark advance automatically adjusted with changes in compression ratio. Dimensions (approx.): 61"H x 60"L x 39"W

The CFR F-2 is nearly identical to our CFR F-1 model, which produces test results by the Research Method (ASTM D 2699 and ISO 5164) for less severe engine conditions. A combination Motor and Research unit is also available which provides the capability to switch between the two methods with only minor equipment adjustments.

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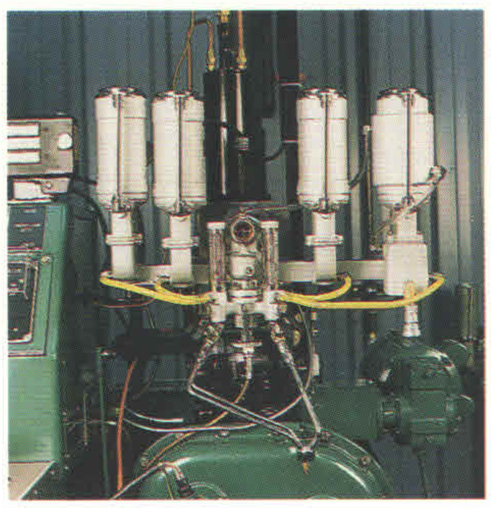
Key Design Features

Variable Compression Cylinder
A variable compression cylinder allows the compression ratio to be changed during engine operation. The available range is 4:1 to 18:1, which allows testing a wide range of fuels. A special overhead valve mechanism provides constant valve clearance as the compression ratio is adjusted. The integral head design provides for improved reliability as well as accuracy of results.

Crankcase
The CFR-48D crankcase combines durability with simplicity of design. All CFR engines use the same cast-iron, box-type crankcase, which features removable side doors and gear cover for easy measurement and repair of critical internal components.



Carburetor
Fuel/air ratios are easily adjusted with this single-venturi carburetor by varying the fuel level. The fuel level is always visible to the operator for easy reference and recording. The carburetor is available in multiple jet and venturi sizes for all applications. Both three-bowl and four-bowl models are offered, as well as various carburetor cooling options.

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Other Important Features

- **Safety systems** provide engine shut-down when any of these conditions are experienced: electrical power loss, low oil pressure, loss of cooling water, or electrical overload of the synchronous/ reluctance motor.
- **Jacket coolant condenser** is of the thermal-syphon, ebullient, recirculating cylinder jacket type. While very simple in design it maintains constant cylinder water jacket temperature for stable operation.
- **Synchronous/reluctance motor** of three-phase design provides power for starting and absorbs the engine's output to maintain constant speed during operation.
- **Air humidity control equipment** is supplied to condition the engine's intake air to between 25-50 grains of moisture per pound of dry air as prescribed in the ASTM method.
- **Pressure lubrication** is used to lubricate all bearings and critical moving parts. External oil pump permits access to the main oil supply line for filtering, cooling or flow measurement.
- **Electronic ignition system** is a condenser-discharge type with coil and distributor. The adjustable spark timing is factory set in accordance with the ASTM method.

Equipment Options for the CFR F-2 Unit

Variable Voltage and Cycles	50 Hz or 60 Hz models are available to suit local requirements. The synchronous/reluctance motor is available in many three-phase voltages.
Motorized Compression Ratio Changer	A touch of the lever controls cylinder height, eliminating manual hand-crank height adjustment.
KVA Transformer	Converts 190, 200, 208 or 220 volts to 110 VAC (50 Hz or 60 Hz). Another option converts 240 volts to 120 VAC (50 Hz or 60 Hz).
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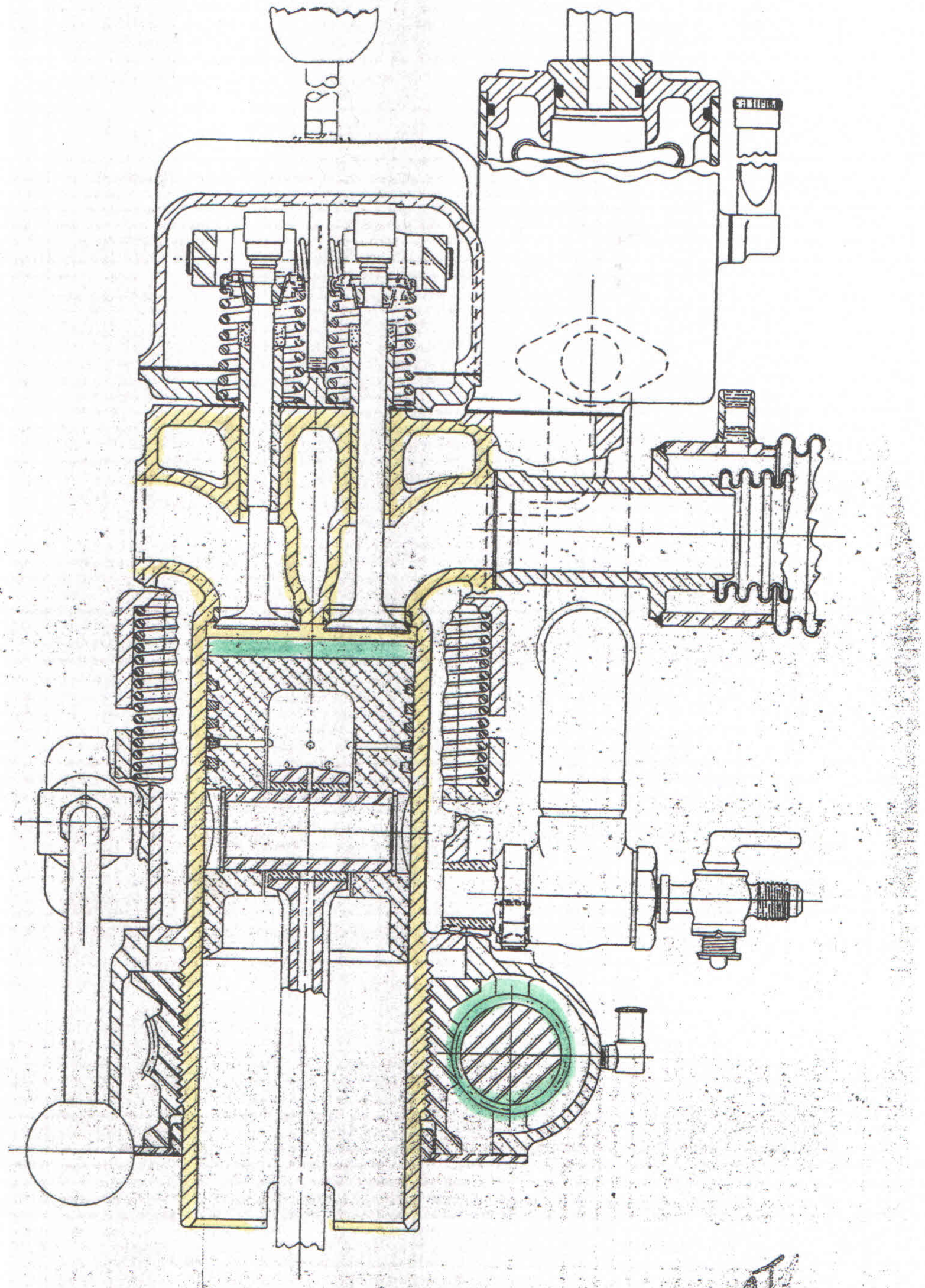


FIG. 20 Cross Sections of Cylinder Assembly

COPPE

DATA	Rio, __/__/200

FOLHA	1/1

CLIENTE: Alunos

AMOSTRA: Aula

TEOR DE ALCOOL (AEAC): Ø %

OCTANAGEM
MÉTODO
MON

PADRÃO 84	AMOSTRA	PADRÃO 85
70	50	40

Nº DO CERTIFICADO
LMT-001

NÚMERO e ALTURA DA CUBA		
(1) 1,1	(2) 1,1	(3) 1,1

TEMPERATURAS	
H_2O	212 ºF
ÓLEO	100 ºF
AR ADM.	105 ºF
MIST.	320 ºF

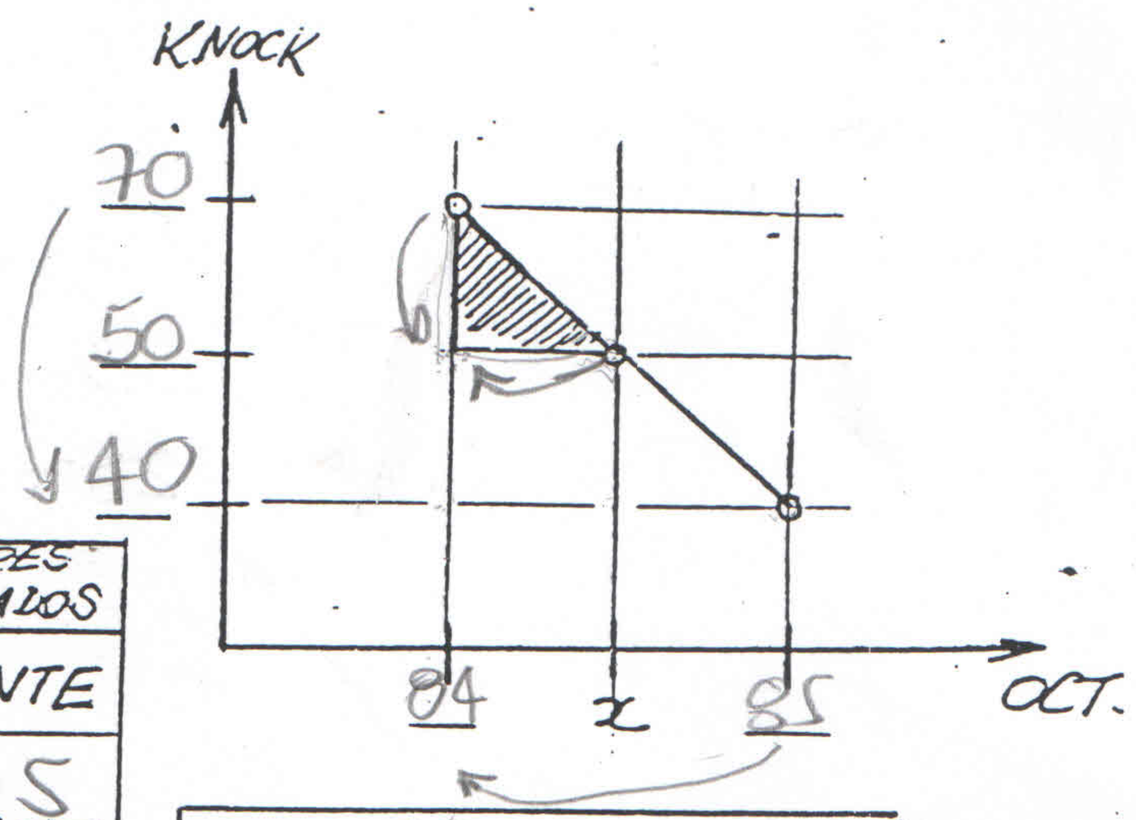
PRESSÃO BAROMÉTR.
760 mm Hg (29,92 in Hg)
AJUSTE MICROM. Ø

ALTURA CILINDRO
0,____ in

DETONATION	
METER READING	__,__
SPREAD	__,__
TIME CONSTANT	._____

VALORES ESTIMADOS
CLIENTE
84,5
LMT
MON
84,7

(_____)



$$\frac{70-50}{x-84} = \frac{70-40}{1}$$

$$x = 84 + 1 \times \left(\frac{20}{30}\right)$$

RESULTADO FINAL	
x = 84,7	MON

OPERADOR(ES)	Nauberto

Universidade Federal do Rio de Janeiro
DEM / EE — PEM / COPPE
Laboratório de Máquinas Térmicas

PROJETO OCTANO (modêlo)

CERTIFICADO DE ENSAIO NO MOTOR ASTM/CFR - OCTANO

Certifico que nos ensaios de octanagem com o combustível "Amostra", abaixo especificado, realizados em .... / .... / 20..... no **Laboratório de Máquinas Térmicas – COPPE/UFRJ**, seguindo os procedimentos ASTM D-2699 (**RON**) e D-2700 (**MON**), foram obtidos os seguintes resultados:

Ref.: Projeto Coppetec PEM – 0000

Combustível: **GASOLINA** Amostra: **AULA**

Teor de Álcool: **0 %**

Resultado MON: **85,2**

Resultado RON: **95,0**

Índice Anti-Detonante $\left(IAD = \frac{MON+RON}{2}\right)$: **90,1**

Rio de Janeiro, ... de ..... de 20.....

Chefe do Laboratório de Máquinas Térmicas

LMT – 19 / 11 / 2011

GASOLINAS AUTOMOTIVAS

A - refinaria

C – distribuidoras

(+20% AEAC)

[ ] Comum } **IAD = 87**

[ ] Aditivada

Premium } **IAD = 92**