



# Protectofier SERVICE MANUAL

FOR ALL PROTECTOFIER COMBUSTION SAFEGUARDS

## SPECIFICATIONS

**Ambient temperature:** Minus 20° to plus 125°F  
**Flame response:** 2 to 4 seconds (0.8 sec. available)  
**Voltage/Frequency:** 120V AC  $\pm$  10%, 50-60 Hz  
**Voltage at E terminal to ground:** 390V AC  
**Voltage at UV terminal to ground:** 590V AC  
**Rating:** 125VA pilot duty  
**Power consumption:** Single burner—35VA or less  
 Multi-burner—10VA for each additional burner

## FEATURES

- Flame failure response, 2 to 4 seconds
- Plug-in solid-state circuitry encapsulated, immediate response (FLAME-PAK)
- Enclosed, interchangeable plug-in relays
- Operates with flame rod and/or P-C II ultra-violet sensors
- Built-in flame response light(s)
- TELEFIER first-out flame indication
- Components and terminals on top of chassis
- All wiring under chassis

### IMPORTANT

Read entire PROTECTOFIER service manual and refer to applicable wiring diagrams and operating sequence before attempting to install, operate or service control system.

## APPLICATION

Single or multi-burner PROTECTOFIER monitors gas or oil burners. It responds to the presence or absence of flame to prevent build-up of combustible fuel mixtures in ovens, furnaces, boilers, and other heating equipment.

## COMPONENTS

**FLAME-PAK** (SS100A) the plug-in electronic sensing unit provides immediate response via the flame rectification principle. Sensing is achieved either by (1) a flame rod which creates a DC signal to the FLAME-PAK, or by (2) the P-C II U-V Scanner in

which a DC signal is developed by an ultra-violet sensitive tube. In either system, if the signal from the flame to FLAME-PAK is interrupted, the circuit to the fuel valves is broken, and can energize an alarm circuit if required.

**Check Relay** (ACF, plug-in type) makes certain that PROTECTOFIER is functioning properly. It is energized thru N.C. contacts of the Flame Relay. Failure of the Check Relay to prove safe-start check will prevent ignition and energizing of fuel valve.

**Flame Relay** (ACF, plug-in type) responds to FLAME-PAK operation energizing circuit to fuel valve.

**Load Relay** (ACF, plug-in type) is used on multi-burner units to energize fuel valves after all flames are proven. It is energized thru series circuit of N.O. contacts of all flame relays. Loss of flame signal from any one burner position de-energizes the load relay, which in turn de-energizes the fuel valves.

**NR Relay** (ACF, plug-in type) is used on all automatic NR units to provide non-return of ignition after flame failure. Contact of NR relay provides power to the thermal circuit breaker following a flame failure causing thermal circuit breaker to trip. Manual reset of thermal circuit breaker is required.

**Thermal Circuit Breaker** (lock-out switch) is required for automatic units to provide ignition trial timing. The thermal circuit breaker "latches-out" after failure to prove flame within ignition trial time and cannot re-start until breaker is manually reset.

**TIMOFIER** (U300M, plug-in type) is a non-adjustable motor driven timer used on manual units (VT, VLT) to provide purge time and ignition trial time. Purge timing should allow system to have a minimum of four fresh air changes.

**TIMOFIER** (U300A, plug-in type) is a non-adjustable motor driven timer used on automatic units (VBT, VBLT, VBT-NR, VBLT-NR) to provide purge time and ignition trial time. Purge timing should allow system to have a minimum of four fresh air changes.



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ELECTRICAL SAFETY EQUIPMENT

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## COMPONENTS (continued)

**Purge Timer** (SST, plug-in type) is a non-adjustable solid state timer used on Form 7256BT-NR and Form 76057-BT to provide purge timing. Purge timing should allow system to have a minimum of four fresh air changes.

**Transformer** (SS3CP, plug-in type) provides low voltage for FLAME-PAK circuit and power source for E and UV terminals.

**Test Jack** provides convenient checking of flame signal by placing a DC microammeter in series with the flame rod or P-C II ultra-violet Scanner (see Servicing Sec. II E).

**Flame Response Light(s):** Neon indicator bulb(s) energized with flame(s) present.

**TELEFIER:** Flame-fault indicator lights for multi-burner systems instantly shows exact burner position causing shutdown.

**Flame Rod or Ultra-violet Scanner:** (either or both can operate in the same PROTECTOFIER system). The P-C II ultra-violet Scanner can be used with gas or oil flame. It is compact, containing only an ultra-violet sensing tube for direct 2-wire connection to PROTECTOFIER. See Bulletin UV-787-R3.

### CAUTION

Installation, operation and maintenance shall be performed by qualified personnel.

**Disconnect power** to the PROTECTOFIER when removing or inserting plug-in components to prevent improper logic sequencing, possible electrical shock or damage to components.

## INSTALLATION

**Mounting:** PROTECTOFIER can be mounted in any position and in any type control panel. The distance from flame depends upon signal current from supervised burner.

- Install only in an area of less than 125°F.
- Flame rod should be mounted permanently in the path of the pilot flame where it can intersect the main burner flame.
- U-V Scanner should be mounted to sight intersection of pilot and main burner and must be shielded from any source of ultra-violet except that of the flame position it is monitoring.
- Adequate provisions should be made to the burner(s) (mechanically or electrically) to prevent the possibility of sensing the ignition spark by the ultra-violet scanner.

### IMPORTANT

**Wiring:** Connections to PROTECTOFIER must be made at terminals in accordance with wiring diagram furnished for a specific application. Wiring diagram and sequence of operation are available upon request.

### CAUTION

Failure to observe safe procedures may result in electrical shock, fire or explosion.

## SERVICING GUIDE

### SEC. I VISUAL INSPECTION

Most operational failures can be remedied by following simple service procedures. However, before servicing is started on the PROTECTOFIER it is necessary that—

- All wiring should be checked.
- All terminal connections must be secure.
- Plug-in relays and FLAME-PAKS must be properly and securely inserted.

### SEC. II EXTERNAL ELECTRICAL INSPECTION

- Voltage to the terminals on the PROTECTOFIER chassis L1 and L2 should be 120V AC  $\pm$  10% 50-60 Hz.
- External limit circuitry should be functioning and allowing uninterrupted voltage to proper PROTECTOFIER terminal.
- Pilot Valve (if it fails to open)
  - Check voltage at pilot valve terminal on the PROTECTOFIER chassis. If there is no voltage see Sec. III Internal Service Guide.
  - If voltage is present, check valve coil for an open circuit.
- Ignition of Pilot (if pilot does not ignite with combustible mixture present).
  - Check voltage at ignition transformer.
  - Check if ignition transformer is providing spark at the spark-plug.
- Pilot (if pilot ignites for brief moments).
  - Check input signal by placing a DC microammeter — dual scale (0-50 for flame rod) (0-200 for U-V Scanner) in series with the flame signal thru test jack on the chassis, or by removing wire on flame terminal (E or UV) and externally placing meter in series. **CAUTION:** Do not ground flame rod with the meter in series; damage to the meter may result. With flame rod operation, a 2-microampere signal is sufficient, but due to flame fluctuations 5 microamperes or more is recommended. With U-V Scanner operation a 10-microampere per second pulsing signal is required (signal may be lower if pulse rate increases).
  - If low signal occurs with flame rod operation
    - Check position of flame rod in pilot; should be in the outer cone of the flame.
    - Check for proper air-gas mixture.
    - Check for leakage. Check for proper nominal voltage on PROTECTOFIER sensor terminals with sensitive VOM (E to ground terminal 390V AC, UV to ground terminal 590V AC). Measure terminal



## SERVICING GUIDE (continued)

voltage with sensor wire connected and disconnected from terminal, voltage should be identical in both cases. Voltage drop of 10 volts AC or more indicates excessive leakage. Consult Flame Sensor Wire Installation Instructions.

### 3. With U-V Scanner operation

- Check position of U-V Scanner for maximum U-V signal.
- Check for proper air-gas mixture.
- U-V tube must be clean.

### F. Main Valve (if it fails to open).

- Check voltage on chassis. If there is voltage at the main valve terminal after proper sequence, check valve coil for an open circuit.
- No voltage at terminal indicates:
  - Flame relay is not energized.
  - FLAME-PAK is not energized.
  - Check for short circuit to main valve.

All of the above possibilities are given in Section III.

## SEC. III PROTECTOFIER INTERNAL SERVICE GUIDE (use only after visual and external electrical inspections have been made).

### A. Check Relay:

All controls have safe start/check, provided by a Check Relay. This relay is energized through a series circuit consisting of external safety limit switch(es) (SEC. II-B) as well as safe start position of flame and load relay contacts, TIMOFIER contact, and safety lockout switch contacts as applicable to the specific PROTECTOFIER used. Consult wiring diagram provided with control.

### B. Flame Relay:

This relay responds to an amplified signal from the FLAME-PAK when flame is present. If flame relay does not pull in:

- Remove wire from E or UV terminal and substitute with flame simulator between E or UV terminal and ground.
- Interchange the FLAME-PAK; replace if needed. Interchange the Flame Relay; replace if needed. Check position of the flame rod for signal (see Sec. V).
- Check for leakage, flame rod or Scanner wire to ground, with an ohmmeter. Leakage resistance should be in excess of several megohms. This leakage check should be made with wire removed from PROTECTOFIER E or UV terminal.

## SEC. IV OPERATIONAL CHECKS

- If the pilot does not light, the cause may be in the safe-start circuit. The Check Relay will not energize if any one of the N.C. contacts in series with the Check Relay is open.

- Refer to wiring diagram and make continuity check.
- Check pilot valve and ignition transformer.

- If pilot lights but no flame response is obtained check for signal at E or UV terminal (see E Sec. II).

### C. If Flame Relay will not drop out:

- First remove wire from chassis E or UV terminal.
- Interchange FLAME-PAK; replace if needed.
- Interchange Flame Relay; replace if needed.
- Interchange flame sensor; replace if needed.

## SEC. V TESTING FLAME RECTIFICATION

- Flame rod signal can be tested by connecting a DC microammeter in series with flame rod. This measures the actual flame current flowing in microamperes — (millionths of an ampere).

### B. Testing ultra-violet flame sensor:

Sensor signal can be tested by putting a DC microammeter in series with the sensor wire connected to the UV terminal (see Sec. II E). The amount of current flowing through the U-V sensor depends upon several conditions.

- Proper sighting of flame. Flame should be visible over the entire viewing port area.
- Sensor should be mounted as close to the flame as possible. Cooling may be required to keep sensor temperature as low as possible. (Note! The sensor is rated at 100° C maximum. However, as temperature increases, sensitivity decreases).
- U-V tube, lens in heat seal assembly (if used) and sighting tube must be kept clear. Smoke in the sighting tube or dirt on the lens or U-V tube absorb U-V thereby reducing signal.
- If all of the above mentioned have been checked and the U-V sensor shows a very low signal, or no signal on the microammeter, the U-V sensor should be replaced with a known working unit.

The microammeter should have a dual scale range (0-50 for flame rod) (0-200 for U-V scanner). A protective circuit is recommended because, among other things, accidental grounding of flame rod could burn out the microammeter. A protective circuit can be made with two 500 ma silicon rectifiers; one rectifier with its positive and negative leads connected to corresponding positive and negative terminals of the microammeter, and the other rectifier connected just the reverse of the first one.

- The positive terminal of the meter connects to E terminal at the PROTECTOFIER, and negative terminal connects to the flame electrode.
- The Flame Relay of the PROTECTOFIER will pull in at a flame current of 1.0 to 1.5 microampere. However, for stable operation, flame current should be greater than this. Currents of 5 to 20 microamperes (and upward) are common.
- The amount of current flowing through flame depends upon several conditions:
  - Position of flame rod relative to flame; best position is usually found in outer, rather than inner, cone of the flame.

## SERVICING GUIDE (continued)

2. Blow-off could also cause absence of flame current. This condition is often the result of excessive fuel and air velocity at the burner fuel outlet, and the flame does not have a chance to be grounded by establishing contact with grounded metal of the burner.
3. High resistance to ground can also cause insufficient current flow to PROTECTOFIER. This could result from carbon deposits on flame rod.
4. Poor insulation characteristics of flame rod or flame rod wire could permit grounding of signal current or leakage of signal current to ground. Grounding or leakage to ground bypasses the rectified current flow through the flame and the 50-60 Hz AC current flow cannot cause the amplifier to conduct.
5. Prolonged grounding of sensor or sensor wire can damage SS100A FLAME-PAK and/or SS3CP transformer. Excessively hot transformers or blistering of SS100A FLAME-PAK indicates a grounded wire or sensor.

### CAUTION

Recommended operating temperatures and voltage must be followed.

Complete shutdown and restart should be made at frequent intervals to check the PROTECTOFIER flame safeguard and associated devices for proper operation.

Where pilots are used to ignite main burners, the flame sensor must be positioned to detect the flame at a point where the pilot flame at its minimum firing rate will reliably light the main burner.

Flame sensor(s) must be checked frequently to ensure correct positioning as well as cleanliness and/or damage that could cause improper operation. Operating temperatures should not exceed 212°F (100°C) for the U-V sensor and 600°F (316°C) on the flame rod insulator.

## FLAME SENSOR WIRE INSTALLATION INSTRUCTIONS

Both proper wire selection and routing are essential to the reliable operation of the combustion safeguard.

The wire must be rated for a minimum of 600V and for the maximum ambient temperature. Sensor wire

may be either solid or stranded and should be plastic insulated such as TW, TH, THHN, or MTW. Number 14 AWG wire is normally used - minimum wire size is 18 AWG. Heavier wire may produce a slightly higher micro-ampere reading. Cloth, rubber, or asbestos insulated wire, microphone cable, twisted pairs, and multi-conductor cables should not be used due to their contaminant absorption and/or capacitance characteristics. The wire should not be spliced nor should pulling compound be used.

Flame sensor wire lengths less than 50 feet may be combined with nominal amperage 115V 60 Hz control wiring. Wire lengths over 50 feet should be run in a separate conduit. Wire lengths exceeding 150 feet are not recommended although lengths in excess of 250 feet have been used successfully. If lead lengths are over 150 feet, moving the combustion safeguard closer to the burner is recommended. If distances over 150 feet cannot be avoided, a low capacitance shielded cable such as RG62AU should be used. This cable is available — see Price Bulletin PAR. The maximum distance between the flame sensor and the combustion safeguard depends upon burner adjustment, sensor, routing, wire and external sources of interference.

## RG62AU COAXIAL SHIELDED CABLE

Flame sensor wire acts like a capacitor to the conduit which reduces the sensor operating voltage and lowers the returned signal. The lower the capacitance of the wire, the better the signal that can be returned to the flame safeguard. **To achieve maximum distance**, the shield of the RG62AU cable should be floating (not grounded) at both ends. **To minimize external coupling interference**, the shield should be grounded at both ends although this will reduce the lead length that can be satisfactorily run.

External electromagnetic radiation will adversely affect operation of the flame sensor and combustion safeguard. Sensor wire must never be run with power wiring such as motor control, high voltage wiring such as ignition transformers or direct current wiring such as SCR motor control, proportional motors and thermocouple wires. Conduit should be routed away from high current devices such as motors, transformers or buss bars, especially if they have a direct current component. Sensor wire must be kept away from induction furnaces and powerful R.F. transmitters.

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INSTALLATION, OPERATION AND MAINTENANCE SHALL CONFORM WITH NATIONAL FIRE PROTECTION ASSOCIATION STANDARDS, NATIONAL AND LOCAL CODES, AND AUTHORITIES HAVING JURISDICTION. ANY MODIFICATION VOIDS APPROVALS.