

**Transfair Engineering:**

## **Application Note for Inficon Ecotec Leak Detectors in the Leak Detection of R600a (Isobutane) Household Refrigerators**

**Author: Walter Dirk Adler**

### **1. Problem**

Household refrigerator producers in mayor parts of the world – except main producers in USA – are using as foam blowing agent Cyclopentane, mainly in the version Cyclopentane 70 with Iso-Pentane and/or with other Hydrocarbons, even Isobutane.

The mass spectrometric measurement of Isobutane use molecular fractions with Atom mass weights 41, 42, 43 and 58, which are also produced from Cyclopentane, Iso-Pentane and some other Hydrocarbons entering into the mass spectrometric leak detector. On an already foamed refrigerator using such blowing agents such gases from the foam produce signals in the range up to 40-50g/a. The today's total acceptable leak rate on such systems only filled with 30-120g R600a on all joint together is only 0,5g/a, with is far underneath the signals of Pentane fractions of the foam.

Even by deduction the background signals (ZEROing), the signals from foam blowing agent is so strongly fluctuating on distance to foam and geometry of the refrigerator, that failure alarm is received regularly and the method is very unreliable, so that only larger leaks could be eliminated (>4-5g/a).

But this is not only a specific problem of Hydrocarbons used in refrigerators, also the solutions as favored in USA face the same problem: Hydrofluorcarbons HFC-134a as refrigerant is measured with atom mass 69, 83 and 51, but the foam blowing agent HFC-245fa produces inside the mass spectrometer the same molecule fractions, so that the very high, fluctuating background signals of foam HFC-blowing agent prevent reliable leak measurement after filling such a refrigerator with refrigerant.

### **2. Consequences**

Under these conditions it does not make sense to test refrigerator cooling circuit leaks already filled with R600a, if the cabinet was foamed with Pentanes.

The only reliable leak test method on such refrigerators is **Helium leak detection** with mass spectrometers like Inficon Protec before filling with R600a, which can reach such a threshold value of 0,5g/a in a reliable way.

**But how the closing of the filling hole and – if two side evacuation was practiced - the service tube on the filter dryer can be controlled reliably?**

In the past there was no real chance to control reliably the filling tube closing leaks (or any other joint) of a system already filled with R600a on the required level of 0,5g/a, if Cyclopentane foam was used. No leak detector on the market including mass spectrometers, like Ecotec II, Ecotec 500, could reach under these conditions trigger values as needed to avoid repairs during refrigerator lifetime.

### 3. New Inficon Ecotec E3000 with fingerprint solution

Now Inficon has with the Ecotec E3000 a technical solution. The first time we can control the closings of the filling tube and the service tube on the filter dryer with the required trigger value as needed today for R600a household refrigerators to avoid repairs. With an algorithm of evaluation of the molecule fractions quantities – a pattern, which is specific for Cyclopentane, Iso-Pentane or for Isobutane (R600a) the sensitivity interferences are reduced by a factor of 100 so that the background signals of the pentane of foam up to 40-50g/a can be squeezed underneath of level of the trigger of 0,5g/a, to get quite reliable leak alarms. We still are near the trigger value and we could get sometime still failure alarm, so that we have to repeat the leak test.

Let's take a closer look on the **conditions of R600a refrigerator leaks and today's leak standards:**

### 4. Pressure conditions on a R600a refrigerator cooling circuit

A **R600a refrigerator cooling circuit** without compressor run has about 2 bar overpressure (300kPa abs.), with compressor run the high pressure side (compressor, gas outlet, if exist on the model, oil in- and outlet, condenser, anti-dew coil, filter dryer), is in the range of 8 bar rel. (=900kPa abs.) and the low pressure side (evaporator, heat exchanger, suction tube, refrigerant filling tube) about -0,5bar (=50kPa abs.).

### 5. R600a household refrigerator leak standards

**R600a household refrigerator leak standards** today accept a maximum **leak of 0,5g/a on all joints together**

- on high pressure side joints under about 8 bars during compressor run,
- on all joint under about 2 bars without compressor run (about 50% of refrigerator life time)

**and on joints on the low pressure side** (-0,5 bar) during compressor run **should not suck in air** (80% N<sub>2</sub> and 20% O<sub>2</sub>) **more than 0,01g/a**. By this way such a system can survive for 15 year. We can measure per joint the 0,5g/a only if we have experience that we can exclude to have on the same refrigerator 2 leaks above or just underneath the trigger value. But more correct is to register all leak rates not only the ones above the trigger value and to check if in total they are still underneath the trigger value. The new Ecotec E3000 can be set to this mode.

### 6. Quality Data recording

The new Ecotec E3000 allows now such a proceeding to control the total measured leak rates of a set of leaks in the so called "I-Guide-mode", but we still cannot use it without a data recording system, because we have to use different machines on 3-4 different places

- Helium leak detection of foamed in evaporator joints,
- Main helium leak detection of joints after cooling circuit assembly and brazing,
- Filling tube sealing (without compressor run)
- Second evacuation tube on filter dryer (with compressor run)

Only if we link these machines together to a quality record system with bar code or RFID reader we can manage it.

## 7. Leak control on the filling tube closing

**Leak control on the filling tube closing** can be done by the Ecotec E3000 with a trigger value of 0,5g/a R600a = 6,65 E-6 mbar l/s at 20°C. This is the maximum acceptable leak if the compressor is not running. If Inficon is right with the new fingerprint algorithm, the interference by Pentane molecule fractions could be pushed underneath the threshold value of 0,5g/a, at least in a way, that if no leak is detected and the work was correct done, we should not have a filling tube leak; and if a leak is detected, we have to repeat the test, to eliminate fail alarm of interferences of Pentane in foam, before we let it repair.

## 8. Equivalence of leaks for air, Helium or R600a

**But how this measured R600a leak rate correspond to air sucked into the cooling system with -0,5 bar during compressor run on the low pressure side?**

All low pressure joints - except the filling tube sealing – can and must already be tested with Helium under 7-8 bar pressure to eliminate leaks on low pressure side. So it remains only the filling tube sealing leak control. A measured leak rate of 0,5g/a R600a (= 6,65 E-6 mbar l/s at 20°C) with 300kPa abs. inside the tube and 100kPa outside (without compressor run) is equivalent to a leak rate of 0,01g/a 80% N<sub>2</sub> (=2,83E-7 mbar l/s) and 0,00g/a 20% O<sub>2</sub> (=6,11E-8 mbar l/s) with 50kPa inside tube and 100kPa outside (conditions of low pressure side under compressor run at 20°C). So we can measure Ecotec E3000 on this trigger value of 0,5g/a, as new system allows such a strong reduction of failure alarms by it finger print algorithm.

## 9. Leak test on the service tube

The **leak test on the service tube can only be done with compressor run** (900kPa abs.) and a trigger value of 0,5g/a R600a = 7,33 E-6 mbar l/s at 50°C, but it should not be done without running the compressor. If we measure this joint without compressor run with only about 2 bar rel. the corresponding trigger value under these lower pressure has to be 0,07 g/a at 2 bar rel. to be equivalent to the trigger of 0,5 g/a under 8 bar rel. And the instrument set on such a trigger will give permanent leak alarm as result of the Pentanes in the foam or very often fail alarm if the high background is deducted by Zeroing.

## 10. Helium leak detection lines for R600a refrigerators foamed with Cyclopentane

Even with the Inficon E3000 and its new fingerprint intelligence to reduce the Pentane interferences of Cyclopentane foam, these interferences are still near the trigger value. To avoid failure alarm, to increase the reliability and validity of the leak test, the Helium leak test method on nearly all joints is strongly recommended and cannot be replaced by a leak test with Ecotec E3000 only after R600a charging without Helium pre-tests.

For further information see [www.transfair.info](http://www.transfair.info)

Transfair GmbH  
Mörsenbroicher Weg 179  
D-40470 Düsseldorf / Germany  
eMail: [Transfair\\_GmbH@t-online.de](mailto:Transfair_GmbH@t-online.de)