Leakage Current Test at Household Refrigerator Type Urg-129 Base Standard Nasional Indonesia (Sni) 04-6292.2.24-2001 For Safety Equipment

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ABSTRACT

Leakage current testing is one of the types of electrical safety test, where test is intended to determine the level of security of an electronic product in this refrigerator URG - 129. Testing is done by giving some different behavior to the test specimen, ranging from varying the loading rate and the value of the input voltage be changed. To then measured the value of electric current leaking from the installation of ground or body surface of the test specimen. From the analysis of the leakage current values obtained under full load with input voltage of 245 Volts PLN, for earth leakage line (normal) (2458 ± 0335) mA, earth leakage line (single fault) (4.0983 ± 0338) mA, Touch Chassis (single fault) (2.485 ± 0.334) am. Based on the value of leakage current, then the refrigerator Uchida URG - 129 is expressed not meet the requirements as specified in ISO 04-6292.2.24-2001.

Keywords: Leakage Current Test, Refrigerator, Electrical Safety Test, Uncertainty.

INTRODUCTION

Availability the electronic products are safe (Safety) requires an understanding of the dangers that often occur in the product. Although a product that works by using electrical power source and having an electronic component therein, has been confirmed not to give a shock hazard to the user, but sometimes it is undesirable happen too often. The normal leakage current flowing from the AC voltage source toward the ground on the product and return to earth ground via a ground pole on the power cord connector. But not all products are running normally as desired, the leakage current of the circuit is sometimes not fully channeled, so it may be dangerous for users. Therefore it is very testing would need to be done. In this current leakage test selected electronic products are household refrigerator, the importance of this product is safe for the user in addition to its use in day-to- day frequent contact / touched by hand, as well as its segmentation is a member of the family who are generally less understood this. Selected refrigerator Uchida URG - 129 with test requirements based on ISO -04-62.92.2.24-2001 since the product is not yet ISO certified.

The objectives to be achieved Knows the value of the magnitude of the leakage current on the refrigerator with a variety of circumstances. Knowing the value of the uncertainty of measurement of leakage currents occur and assess the security level of a Refrigerator making it feasible or not recommended for use, base on the requirement of ISO 04-6292.2.24, 1001. For the problems that arise, hence the need for restrictions on the problem so as not to widen and simplify the analysis. Limitation of the problem is the test done of leakage current, not to test the electrical safety of others. Tests were carried out on a Household Refrigerator Uchida

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brand type URG - 129. Tests conducted with a reference guide Electrical safety testing of Quartet [3]. Determination of eligibility is based on SNI products 04-6292.2.24-2001.

Based on the background, problems and objectives mentioned above, it will be a few steps in supporting the implementation and completion of this thesis, which are as follows: Study of literature on the concept of Flow Leakage Testing (Current Leakage test). Refrigerator electrical system Uchida type URG-129. Or tester test equipment and specifications used for the preparation of measurement activities and conditions that meet the requirements of measurement. Measuring the value of leakage current on type URG Refrigerator - 129 with several input voltage conditions and different loading. Analyzing data obtained from the measurement results along with the calculation of measurement uncertainty and make conclusizns.

MATERIAL AND METHODS

Flow Leakage Test, to produce a count of security for customers, regulatory agencies usually require a product to be tested leakage current is less than 0.5 mA. With some products are equipped with 3 - prong plugs and safety stickers, leakage currents in high - tolerance of about 0.75 mA, but the limit is 0.5 mA, typical. Since Hippo tests are usually carried out, requires 100 % of every unit in the division of production, and more emboldened since Hippo test, test leakage current path has become mandatory as a design specification or test form, and not as a test of the production division. leakage current test naturally required on all medical products, as production test. Test leakage current drawn by a circuit similar to Figure 1. Measure leakage current in a wide variety of ground conditions without or with line and neutral connections reversed. First voltage provided through normal channels and neutral connections, followed by testing the connection is reversed, and with no ground.

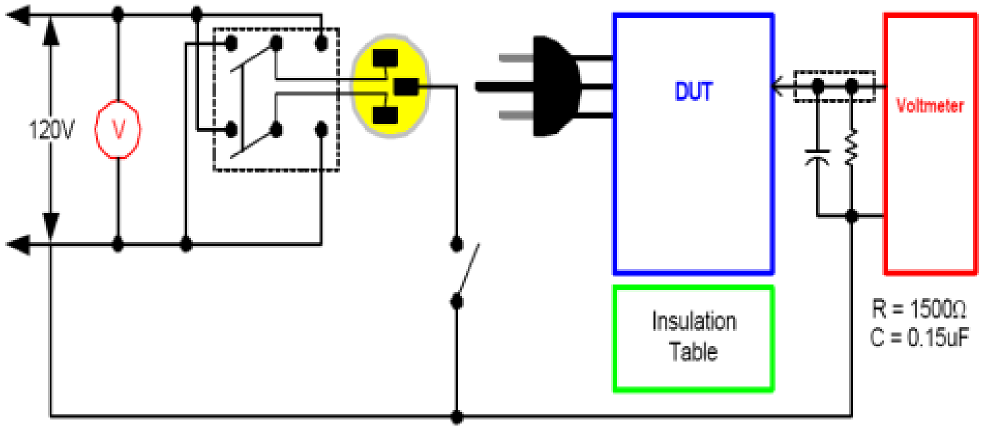

Figure 1. Test circuit for current leakage [4]

Class I products, have basic insulation in combination with the protection of the earth. This product will have a three-prong power connection and ground poles will be connected with any metal parts contained in the product, Figure 2.

Class II product is a product that has a two-prong electrical connector. Class II products not only in isolation but also essentially extra insulation or insulation support. These products are often referred to as double insulation products as protection against shock. As long as there is no ground to discard protection leakage current, leakage current limits of acceptable for Class II products is smaller when compared to the product class I. The picture of the product class II (class 01).

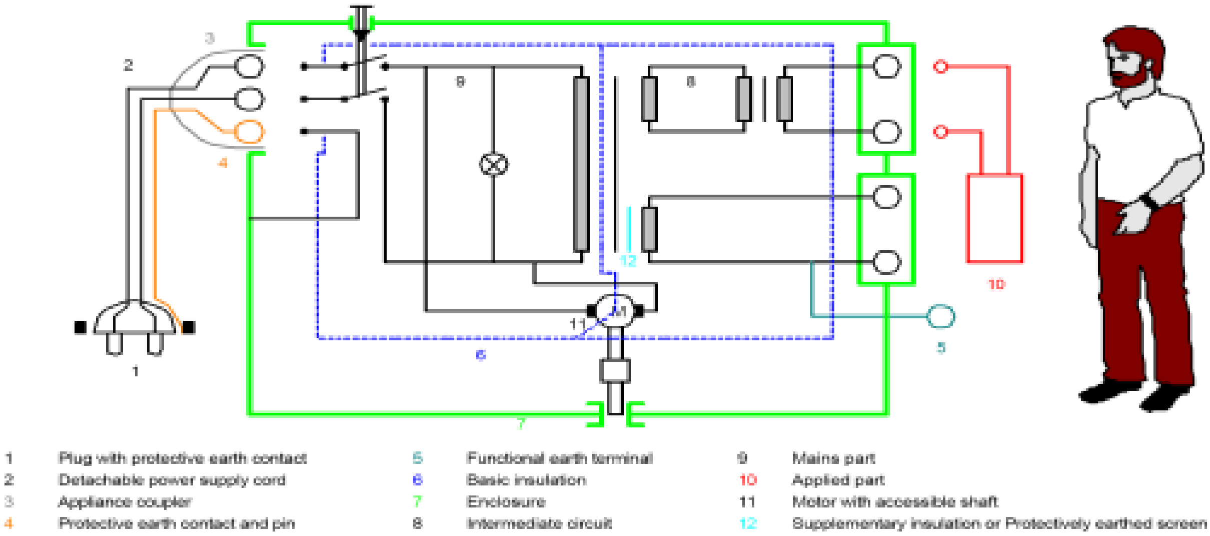

Figure 2. Circuit for class product I [4]

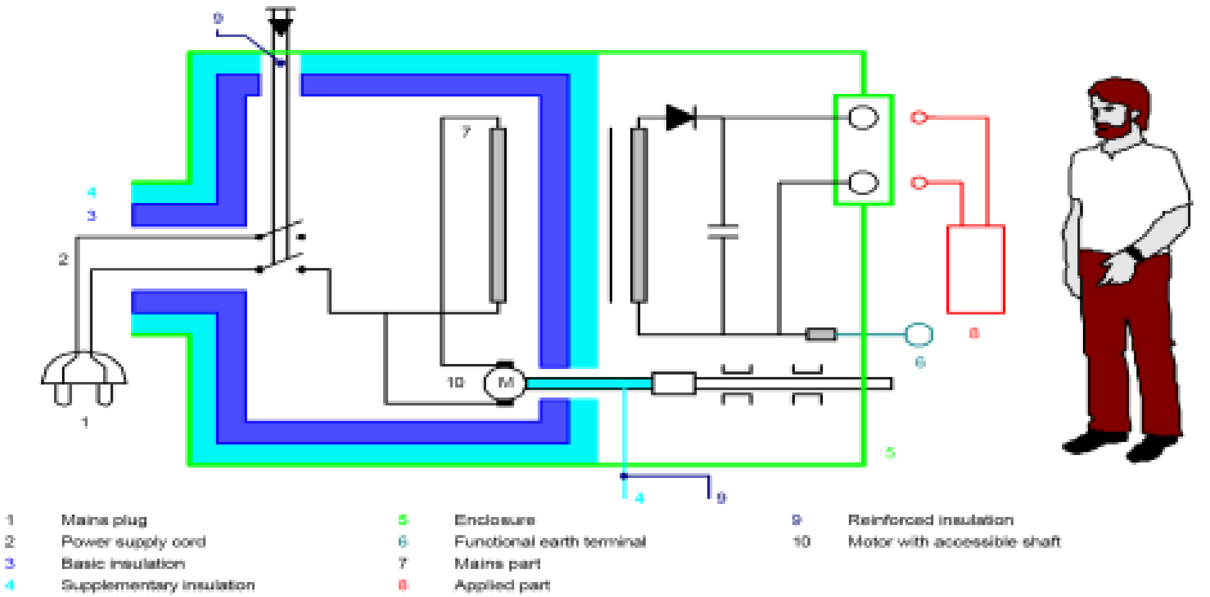

Figure 3. Circuit for class product II [4]

Measurement of leakage current, leakage current measured value compared to the exposure limits for the type of products that are tested classified, parts in contact with the product, (Earth, touch, Patient) and operating the product under normal and single fault conditions. Measurement instrument that is referred to as MD has custody input (Z) 1MΩ and frequency characteristics similar to 1MHz DC current. As depicted in Figure 2.4. Leakage current measured at 2 different conditions, namely Normal operation condition and fault condition. Normal conditions (normal operation) where the product is run on standby and full operating conditions. As for the single fault Events are conditions when the ground detached and neutral connectors apart.

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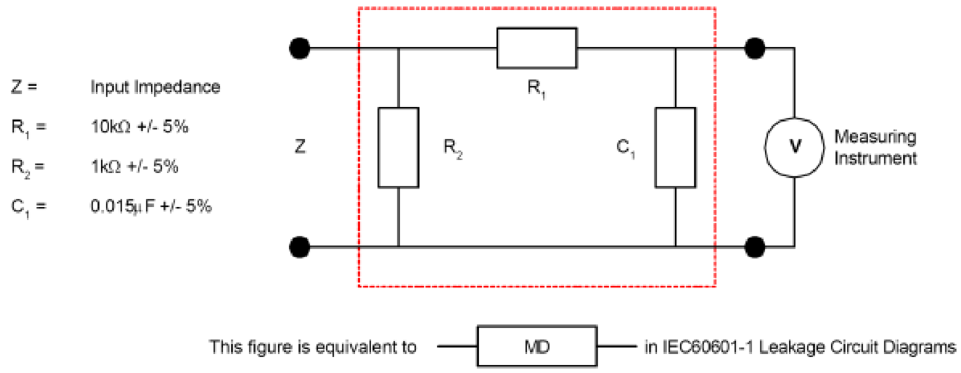

Figure 4. Analogy of the human body or tissue in the IEC60601-1 [4]

Other general rules that should be considered when testing the leakage current is where the products are tested and placed on the surface of the insulation with a minimum distance of 20 cm from the surface of the other metal. Besides the measurement tool and the cord should be positioned as far as possible from sources of electrical voltage open. Earth Leakage Line, the most important activity of the test leakage current for class I products are earth leakage line. This measurement is performed to determine the magnitude of the current flowing back to the ground pole, the electrical connector.

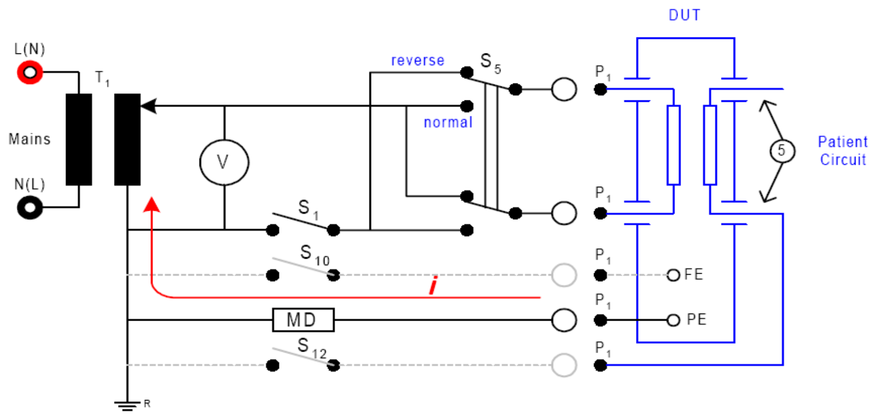

Figure 5. Earth Leakage Current [4]

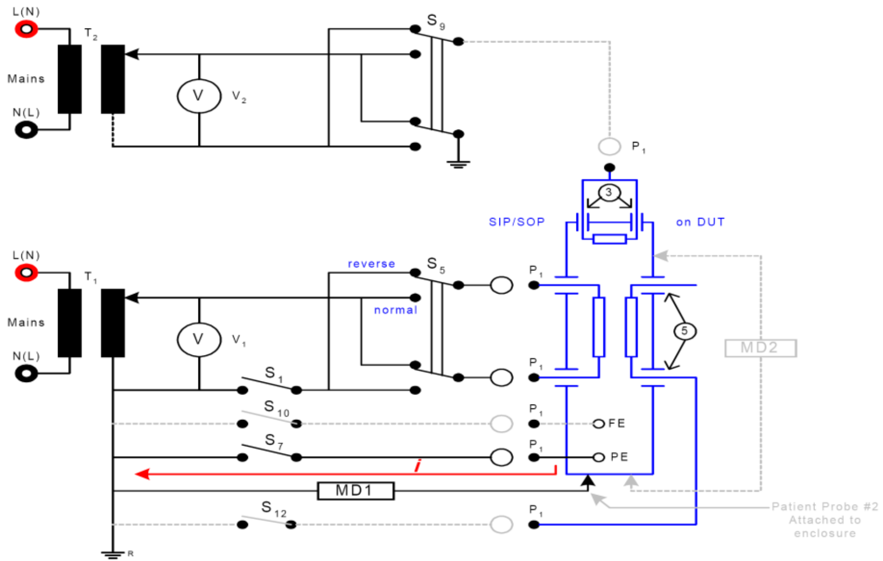

Figure 6. Touch/Chassis or Enclosure Leakage Current [4]

Touch / Chassis Enclosure Leakage Current or, on the measurement is performed to measure the leakage current from all parts of the surface that is not connected to the protective earth, with the exception of parts used.

Measurement uncertainty is the range of values around the expected outcome measurements therein lays the true value of the measured. Calculating the Value of type A uncertainty U_A (U_A) is purely of statistical calculations (repeated measures), Taking the data. Calculate the average, standard deviation and Counting Calculating uncertainty of type A (U_A).

$U_a = \frac{SD}{\sqrt{n}}$ Menghitung derajat kebebasan tipe A (V_A), V_a = n-1 (1)

The next step of type B uncertainty Calculating the value of non-statistical (UB), 3.Menghitung degrees of freedom of each uncertainty type B (VB), counting the combination of uncertainty (Uc)

$$U_C = \sqrt{U_A{}^2 + U_{B_1} + ... + U_{B_n}} \quad (2)$$

Calculate the effective degrees of freedom (V_{eff})

$$V_{eff} = \frac{U_C^4(y)}{\sum_{i=1}^{n} \frac{C_i^4 U^4(X_i)}{V_1}} = \frac{U_C^4}{\frac{U_A^4}{V_A} + \frac{U_{B1}^4}{V_{B1}} + ... + \frac{U_{Bn}^4}{V_{Bn}}} \quad (3)$$

For Veff. determined how many % confidence level, Determining the coverage factor value, Counting U_{range}, UExp = K x U_C
Make reports and uncertainty, Uncertainty of type A is characterized by primary data inconsistency calibration data performed repeatedly at a certain measuring point. So the uncertainty of type A was evaluated using standard statistical methods to access a set of measurements. Characteristics of type A uncertainties include: Results of repeated measurements (X1, X2, X3,..... Xn) and the average value of the measurement results $(\bar{X})$

$$(\bar{X}) = \sum_{i=1}^{n} \frac{X_i}{n}$$

$(\bar{X})$ = Value rate

$\sum X_i$ = Total value of the sampling

n = The number of data collection

Standard deviation is calculated using the equation S(X).

$$S(X_i) = \sqrt{\frac{\sum_{i=1}^{n}(x-\bar{x})^2}{(n-1)}} \quad (4)$$

ESDM (Experimental Standard deviation of the mean) or often referred to as Standard Uncertainty for type A (U_A).

$$ESDM = U_A = \frac{S(X_i)}{\sqrt{n}} \quad (5)$$

Degrees of freedom or Degrees of Freedom (V) will always be given or calculated if the evaluation of type A of Uncertainty documented

$$V = n - 1 \quad (6)$$

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Linear regression Yi = a + bX_i and each pair of observations satisfy Yi = a + bX_i + ei is used to calculate the uncertainty of type A2. Parameter estimation procedure that is widely used is the least squares method, ie by seeking the sum of squares of all deviations from the actual line and the line is obtained by least squares to minimize the sum of squares of all the vertical deviation. Sum of the squares of all deviations or number of error around the regression line can be expressed by the SSR.

$$SSR = \sum_{i=1}^{n} e_i^{\ 2} = \sum_{i=1}^{n} \left(y_i - a - bx_i\right)^2 \qquad (7)$$

Where,
SSR: Sum square of the residuals
yi: Data measurement
a, b: Constants
xi: Setting
the distribution of data around the curve can be explained by a variation Var which can be calculated by the equation:

$$Var = \frac{SSR}{V}$$

RESULTS AND DISCUSSION

In a safety test, leakage current measurement is done based on the data of the reference manual electrical safety test Quadtech [3]. The data obtained is then compared with the requirements contained in ISO: 04 - 6292.2.24 - 2001 as reference standards and reference in determining the feasibility of the security level refrigerators [4].

Equipment Used In Testing:

- Digital Millimeter Sanwa CD-800a, resolution: 0:01 mA accuracy: 2.8% rdg + 5 DGT Thermo-Hygrometer
- Digital Clamp Meter FLUKE-337, 0 ~ 999.9 an accuracy: 2% - 5 counts (10-100 Hz)
- Travo kenika variable range: 0 ~ 250 VAC, 4A, 880 W max.
- MCB: Merlin Gerin: 10A & 6A Matsuka
- StopWatch, the data collection sheet
- Test Chamber 3 sides of a 15mm thick multiplex, matte black

Environmental Conditions Testing

At the time of each test environmental conditions around the Refrigerator URG - 129 should be controlled in such a way to be able to anticipate some of the things that can interfere with the validity of the test. Controlled variables are : temperature (27 ± 2) ° C and relative humidity (relative humidity) (70 ± 5)% RH.

i. Test Preparation, refrigerator before testing leakage current URG-129 was performed as follows:
Specimens or UUT, (refrigerator URG-129) to be started first to the steady state by operating at normal voltage 220 V AC/50 Hz for ± 24 hours.

ii. Availability of measuring instrument, in accordance with the requirements specifications mA current range and voltage measurement 0 ~ 250 Volts AC

iii. Measuring instrument used must be certified and traceable, equipped with the tools required specification information for the evaluation of calculation of uncertainty, namely: accuracy and resolution of the measuring instrument.

iv. Installation testing shall meet the specified requirements, including: using a test chamber as insulation, laying UUT ≥ 30cm distance from other objects containing metal, laying a measuring tool as far as possible from sources of electrical voltage. [4]

v. Chamber of test should be a non-conductor (insulator) to avoid contact between the UUT to the ground.

vi. Availability of load (bottled mineral water, fruits and eggs) to meet four different loading conditions.

vii. Setting up the installation of disconnect switches (MCB) ground and the positive line, to fulfill some kind of leakage current conditions

viii. **Testing procedure:**
Leakage current testing procedures against URG Refrigerator - 129 done by following the following steps :

ix. Refrigerator position on (test chamber) test chamber, and ensure that the refrigerator touch / contact with the earth.

x. Filling of storage space as well as space food ice maker with bottled mineral water, the water in the container / mold ice, fruits, eggs up to ± 16 L.

xi. Turn the thermostat knob to the coldest position (maximum).

xii. Running the refrigerator at a voltage of 220 volts normal PLN, through Travo by regulating the voltage variable.

xiii. Measuring large current flowing through the ground from the refrigerator to the ground connector PLN, using a series of MD and no.

xiv. Record the value of the leakage current in a worksheet (worksheet) is available.

xv. Constantly monitoring the changes in temperature, humidity environment through Thermo - Higro input voltage meters and PLN.

xvi. Perform step 5 to step 7 to obtain repeatable measurement data up to 6 times, for a period of once every 30 seconds.

xvii. Repeat step 4 to step 8 to set a different voltage values every 5 Volt with a range between 180 ~ 250 VAC.

xviii. Repeat step 2 to step 9 by changing the size of the contents of the refrigerator load as much as ± 10 L, ± 25 L, and an empty load, to get the data based on the value of the leakage current of the load difference refrigerator contents.

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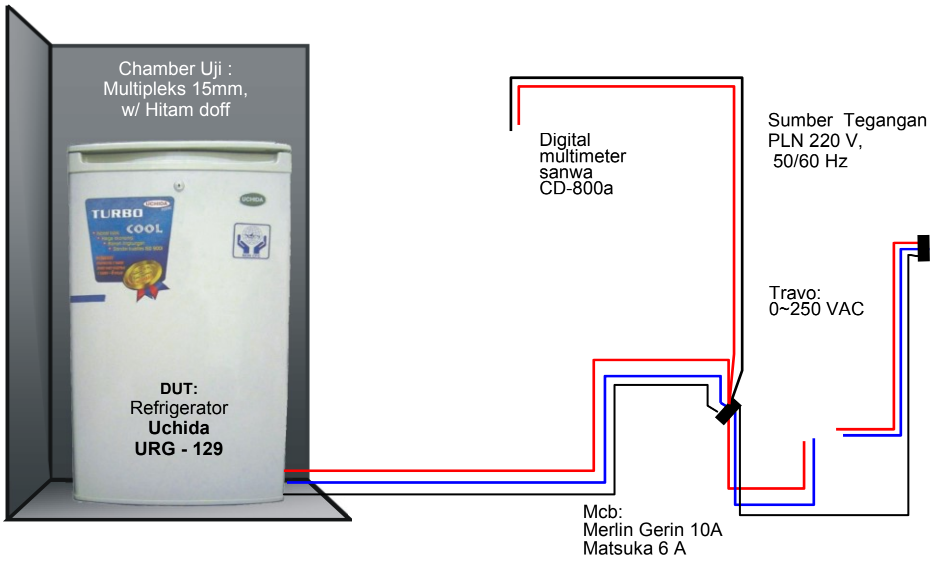

Figure 7. Instalation testing for current leakage

xix. Evaluation of test data, uncertainty evaluation stages of the data, as follows :

xx. Calculate U_{a1}, ESDM = U_{a1} =, Type A Uncertainty is derived from the random effect at each measurement data, with S (Xi) is the standard deviation and n is the number of measurements taken. [3]

xxi. Calculate U_{a2}, $U_{a2} = \sqrt{(SSR/V)}$; Uncertainty derived from measurements based on different voltage range. With SSR is Residual Sum Square and V is the degrees of freedom.

xxii. Calculate U_{b1}, Ustd = U_{b1} = (Resolution x 0.5) / √ 3, Derived from a digital multimeter resolution Sanwa CD - 800a at 0.01mA with Coverage factor √ 3 is based on a rectangular probability distribution, in accordance with the type of digital measuring instruments.

xxiii. Calculate U_{b2}, U_{b2} = (Accuracy / √ 3, Derived from a digital multimeter accuracy Sanwa CD - 800a 2.8 % rdg + 5 DGT with Coverage factor √ 3 rectangular distribution based on the probability, according to the type of digital measuring instruments.

xxiv. Calculate U_{b3}, U_{b3} = (Accuracy / √ 6), Derived from ambient temperature to the factor √ 6 Coverage is based on the probability distribution triangular.

xxv. Calculate U_{b4}, U_{b4} = (Accuracy / √ 6), Derived from input voltage PLN Coverage factor √ 6 based on the probability distribution trianguler.

Uncertainty evaluation value calculation results are recorded in the table Uncertainty Budget at any loading conditions and different types of leakage currents. Expanded uncertainty is the uncertainty of the final measurement value to be written as a report measurement results along with the current value of the magnitude of the average - average, the level of trust or confidence factors and their levels of coverage. The Testing Results, on testing leakage current URG refrigerator - 129, obtained the data - data about the magnitude of the leakage current value according to the type of leak, and with changes in the value of the input voltage is different. Here are presented the measured data in Table 1.

Table 1. The leakage current full load

No.	V input	Earth Line Leakage Current (Normal)		Earth Line Leakage Current (single fault)		Touch Chassis (single Fault)	
		I (mA) (w/MD)	I (mA) (w/o MD)	i (mA) (w/MD)	i (mA) (w/o MD)	i (mA) (w/MD)	i (mA) (w/o MD)
1	180	1,813	1,817	3,018	3,022	1,820	1,827
2	185	1,891	1,902	3,167	3,170	1,898	1,897
3	190	1,955	1,967	3,282	3,293	1,952	1,968
4	195	1,988	2,008	3,277	3,325	2,002	2,032
5	200	1,930	1,950	3,203	3,208	1,940	1,958
6	205	1,955	1,975	3,220	3,235	1,943	1,982
7	210	1,983	2,020	3,260	3,367	1,978	2,058
8	215	2,083	2,098	3,430	3,487	2,063	2,098
9	220	2,220	2,218	3,390	3,505	2,145	2,150
10	225	2,262	2,285	3,727	3,708	2,265	2,262
11	230	2,303	2,328	3,840	3,818	2,318	2,323
12	235	2,373	2,375	3,913	3,933	2,403	2,403
13	240	2,421	2,415	3,965	4,000	2,417	2,433
14	245	2,458	2,452	4,098	4,107	2,485	2,512
15	250	2,483	2,493	4,083	4,118	2,477	2,463
16	255	2,412	2,425	3,867	3,877	2,358	2,357

In the same way, do the test anyway Leaks Average Load Flow Medium, Testing Average Leakage Flow and Minimum Load Testing Leakage Flow without Load Average. Measurement Uncertainty Analysis of Type-A, Recurring uncertainty. From the results of repeated measurement data are used to determine the value of A-type uncertainty. Uncertainty Value Type A searchable via equation (5-8) are as follows: Calculate the average price of all repeated measurements ‚ Calculate Standard Deviation, Calculating Uncertainty repeated readings[3] ESDM = $U_A = s(X_i)/\sqrt{n}$ and Calculate degrees of freedom [2], V= n-1,

It is known that repeated measurement uncertainty can be calculated from the largest EMR, are presented in the table 2. Uncertainty of the results of linear regression (SSR). [2]

Retrieved from error / difference between the distributions of the rate values . Components of the X-axis are the mean value of the measurement data in nine sectors while the test component Y-axis is the value of the uncertainty in each measurement data - the respective sectors.

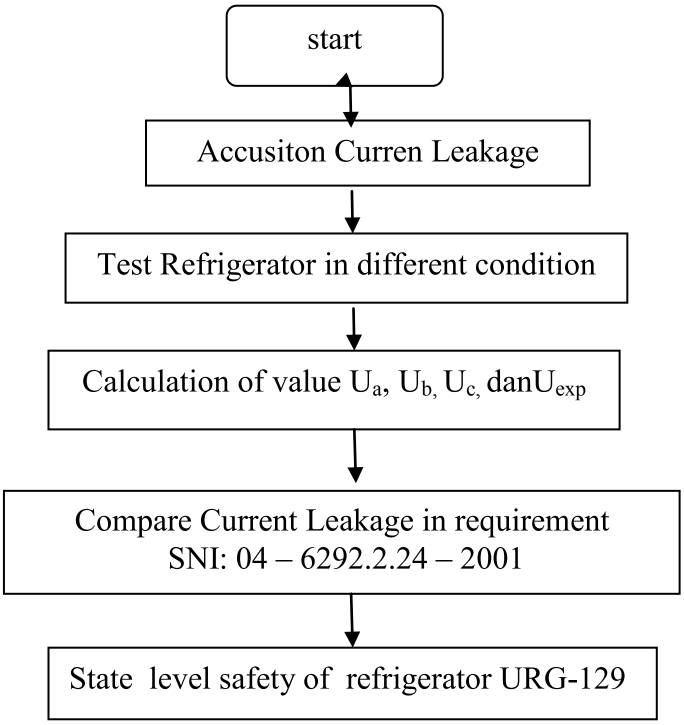

Figure 8. Flow Diagram for Testing

Table 2. Uncertainty value recurring U_{a1}

Current Leakage type	*Full Load*	*Medium Load*	*Minimum Load*	*No Load*
Earth Line Leakage (Normal) w/MD	0.02442	0.01333	0.01563	0.01342
Earth Line Leakage (Normal) w/oMD	0.0263	0.01108	0.01384	0.01438
Earth Line Leakage (Single Fault)w/MD	0.03367	0.01797	0.02066	0.03169
Earth Line Leakage(Single Fault)w/oMD	0.034	0.01783	0.02352	0.03439
Touch Chassis (Single Fault) w/MD	0.01945	0.03468	0.00919	0.01628
Touch Chassis(Single Fault) w/oMD	0.01447	0.03661	0.01222	0.01493

Measurement Uncertainty Analysis of Type - B. [3]

a. Resolution multimeter Sanwa CD - 800a., Specification digital millimeter Sanwa CD - 800a states that for measuring the amount of current, mA resolution tool is 00:01. Thus, uncertainty is standardnya, Ustd ;

b. $UB1 = 0.005 / \sqrt{3} \times 1$ mA = 0.00289 mA Sanwa CD - accuracy multimeter 800a. According to the specification digital multimeter Sanwa CD - 800a, for current measurement, the instrument accuracy mA current measurement range is ± (2.8 % of rdg + 5 DGT). Thus, uncertainty is standard, $U_{std} = UB2 = 0.028 / \sqrt{3} = 0.01617$ mA. $\sqrt{3}$ coverage factor value based on the probability distribution rectangular. Rectangular probability distribution defined as the type of measuring instrument used is a digital measuring instrument.

c. Temperature Environment. Is one factor that has contributed to the uncertainty of measurement, according to data recorded during testing of test room temperature only fluctuates in the range of no more than (27.6 ± 0.4) ° C, then the uncertainty of standardnya, Ustd = UB3 = 0.4 / √ 6 ° C = 0:16 ° C. Coverage factor value.

d. based on the probability √ 6 triangular distribution. Voltage PLN. Has an accuracy of 10 %, √ 6 divider selection based on the range of values around the average point, so the uncertainty standardnya, Ustd = Ub4 = 10 % / √ 6 ° C = 0:04 ° C.

Table 3. Uncertainty value (U_{A2})

Current Leakage type	*U_{A2}*			
	Full Load	*Medium Load*	*Minimum Load*	*No Load*
Earth Line Leakage (Normal) w/MD	0.00517	0.0029	0.00319	0.00267
Earth Line Leakage (Normal) w/oMD	0.00487	0.00267	0.00356	0.0036
Earth Line Leakage (Single Fault) w/MD	0.00868	0.00394	0.00401	0.00706
Earth Line Leakage (Single Fault) w/oMD	0.00645	0.00398	0.00644	0.00599
Touch Chassis (Single Fault) w/MD	0.00376	0.00834	0.00213	0.00321
Touch Chassis (Single Fault) w/oMD	0.00311	0.00893	0.00253	0.00419

Tabel 4. Uncertainty budget full loading

UNCERTAINTY BUDGET *(Full Load)* Earth Leakage Current-Normal-w/MD								
No	*Source of Uncertainty*	Type	Ui	U value (mA)	Prob.Dist	CovF ac.	Ustd(mA)	Vi/ Veff.
1.	Repeatability	A	U1(i	0,0244	T-Std	1	0,0244	5
2.	SSR	A	U2(i)	0,0052	T-Std	1	0,0052	14
3.	Resolusi Sanwa CD-800a	B	U1(i)	0,005	Rectangulair	√3	0,0029	∞
4.	Akurasi Sanwa CD-800a	B	U2(i)	0,028	Rectangulair	√3	0,0162	∞
5.	Temp. Enviro.	B	U3(T)	0,4°C	Triangulair	√6	0,163 °C	∞
6.	Voltage Enviro.	B	U4(V)	0,1 V	Triangulair	√6	0,040 V	∞
7.	Current leakage	Com	Uc	-	Normal	-	0,1709	1199
8.	Conviden level	-			-		95%	-
9.	Current leakage	Exp	Uexp	0,33507	Normal	1,96	-	1199

By the same method, the uncertainty budget medium load and Uncertainty budget minimum load can be calculations. Discussion about the level of security based on the value of the

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measurement results refrigerator when testing Refrigerator URG - 129, which consists of a value - average ± expanded uncertainty, leakage current tolerance is exceeded the maximum (allowable limits) in the standard ISO 04 - 6292.2.24 - 2001 or not. If the average value does not exceed ± ketidahpastiannya allowable limits, then this means that the UUT passed the test. [5] Where the requirement is a maximum leakage current of the Indonesian National Standard 04-6292.2.24-2001 page 14, paragraph 14.2 [5] Class 01 = 0.75 mA and 1.5 mA = Class 1. Because the product is a product class 01 (class I) then limit the maximum value of 0.75 mA leakage current.

CONCLUSSION

Leakage currents occur greater value to 2 times the maximum leakage current value, for class 01 product categories (Class) of 0.75 mA. The relationship between the leakage current to the input voltage PLN, the greater is the input voltage, leakage current value tends to increase. The difference in the rate of loading capacity of the refrigerator contents do not give a significant effect on the value of the leakage current - average. Where the magnitude of the maximum load of 2629 mA. 2.7 mA. at medium load, at 2:56 mA. minimum load, no load at 2,667 mA. The amount of leakage current under full load with input voltage PLN 245 Volt, for earth leakage line (normal) (2458 ± 0335) mA. earth leakage line (single fault) (4.0983 ± 0338) mA. Touch Chassis (single fault) (2.485 ± 0.334) mA. Refrigerator Brand URG-129 does not meet the safety requirements of the leakage current test.

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