AN EXPERIMENTAL INVESTIGATION OF INTERRUPTING PERFORMANCE OF HV EXPULSION FUSES

Shen Meihan

Xi'an High Voltage Apparatus

Research Institute

P.R.China

Abstract: In this paper some factors affecting the arc-extinguishing behaviors of HV expulsion fuse are dealt with and the construction, and behaviors of the newly-developed 11.5-40.5 KV expulsion fuse and its use and prospect in China are introduced. Moreover, suggestions regarding the relevant regulations for interrupting tests of the IEC 282-2 "Expulsion and Similar Fuses" are made.

I General Introduction

The 11.5-40.5 KV HV expulsion fuse has found extensive application in the 10-35 KV power systems in China. Being simple in construction, reasonable in price and convenient in use and maintenance and relatively satisfactory in protection behavior, the fuse, which is well accepted by numerous users, is one of the most widely-used electric HV apparatuses in the power systems in China. It is mainly connected in series on the HV side of the 10-35 KV distributing transformer in urban and rural areas, or installed on the main and branch lines of the distributing networks to protect the transformer and lines from accidents . In the 10-35 KV power systems in China, the number of this kind of fuses is as great as about several millions and its annual output some hundreds thousand each year.

II Investigation of Factors Affecting Arc-Extinguishing Behaviors of the Fuses

Detailed specifications are made in the IEC 282-2 standard and C37.41-1981 of the American ANSI/IEEE standard concerning the interruping behaviors of the fuse. The standards demand that the fuse should be able to make and break the interrupting currrent ratings and any short-circuiting and over-load currents below them, i.e. to make and break 5 series of current values such as I + 5-0%,0.7-0.8 I,0.2-0.3 I,400-500 A,and the 2.7-3.3 times fuse link rating. As these demands are quite severe, and the arc-extinguishing behaviors are affected by a great number of factors, among which are chiefly the material, construction and size of the fuse tube, it is the key problem to design the reasonable fuse construction,to select the arc-extinguishing material with satisfactory properties and to make out the rational fuse size to resolve the contradiction of making and breaking large and small currents. The paper, considering a numerous tests and investigations conducted over the past few years concerning the new type 11.5-40.5 KV fuses and the experience in the manufacturing testing and operation of fuses gained in China for more than 30 years, deals with a few important factors affecting the arc-extinguishing behaviors of the fuse as follows:

1. The Influence of the Material and Size of the Fuse Tube

The fuse tube is the most important part of the expulsion fuse and it consists generally of the inner gas-generating arc-extinguishing tube and the outer protecting tube. When the fuse-element is blown out and the arc is produced, the material of the inner arc-extinguishing tube under the action of the arc, generates a large amount of deionizing gas, thus causing the pressure in the tube to rise rapidly and the high pressure gas injects from the open end of the fuse tube blowing the arc perpendicularly so that the arc is elongated quickly and cooled intensively and caused to be extinguished.

After carrying out investigations and tests of the short-circuiting interrupting current by using gas-generating materials such as plexiglass, PVC, fibere, amino resin cellulose, etc. we have found that with PVC, which has a satisfactory arc-extinguishing behavior, a high impact strength,and a moderate consumption, with gas generated under the action of the arc, a great number of carbonized particles are produced on its surface. Other materials such as plexiglass,amino resin cellulose etc., in spite of their good properties in many fields, the mechanical strengths, mainly the impact strength, are not good enough. After the gas is generated and the arc is extinguished, there are cracks at the bottom end of the inner tube. After the second successive interrupting, the bottom end of the inner arc-extinguishing tube is cracked for 8 to 10 cm, the part broken in pieces flying out of the tube fuse together with the gas so that it cannot be used again. At present, it is considered that only the fiber material is relatively suited for making of the inner arc-extinguishing tube. Therefore, this material is selected for making the arc-extinguishing tube with the epoxy resin cloth wound around it to act as its outer protecting tube so as to increase the strength against mechanical impact. The outer surface of the tube is coated with moisture-proof insulation lacquer. However, the greatest disadvantage of the fiber material is that it is likely to be deformed when absorbing moisture. To combat this drawback, we have designed a fuse tube construction with its top end closed under normal operating conditions to keep rain from getting into the tube directly. It has been proved that the construction in which the top end is closed and step-by-step gas discharge is adopted is successful thus avoiding completely the disadvantages of the fiber.

When the arc-extinguishing material has been selected, another key issue is how to determine the size of the fiber inner arc-extinguishing tube in the fuse tube in order to satisfy the demands of the large and small interrupting short-circuit and overload currents. As in the fuse tube, the arc is extinguished by generating the gas from the inner arc-extinguishing tube, it is clear that, if a larger internal diameter is chosen, the pressure will be moderate when making and breaking the rated interrupting current. However, when making and breaking a small over-load current, the gas will not be generated enough to extinguish the arc because the internal diameter of the arc-extinguishing tube is too larger resulting in an insufficient amount of the gas generated. When a smaller internal diameter is chosen, a sufficient amount of gas will be generated when making and breaking small currents, but there can be cases when an explosion occurs because, when making and breaking the rated interrupting current, the amount of the gas generated is too large and the pressure in the tube is too high so that the fuse tube fails to withstand such a high pressure. As up to now there has been no formula for determining accurately the size of the arc-extinguishing tube, it is mandatory to determine the suitable size of the arc-extinguishing tube through the interrupting tests of research nature. As far as the fuses for different voltage ratings and rated interrupting currents, the size of the arc-extinguishing tubes is different from other. Through a lot of tests and research, we have determined the sizes of the arc-extinguishing tube of the fuses for various specifications for the rated voltage of 11.5-40.5 KV, rated current of 100 and 200 A and rated interrupting currents of 6.3, 8, 10, 12.5 KA. Valuable experimental data have been obtained from hundreds of interrupting tests for various current ratings and relatively deeper understanding has been gained concerning varied factors affecting the interrupting properties. It has been found from the tests that only depending on the suitable selection of the tube material and size, is it still not possible to meet the demands for the fuse tube with the same size to make and break both large and small short-circuit currents. To overcome this difficulty, it is necessary to take steps with regard to the construction of the fuse tube. Furthermore, supplementary technical measures for arc-extinguishing should be taken. This is the second and third problems we are going to discuss in the following.

2. Influence of the Fuse Tube Construction

The fuse tube we have designed is one of the step-by-step gas discharge construction (see Fig.1), where the button-type fuselink is employed (see fig. 2). The fuselink is inserted from one end and the button is pressed by the pressure-releasing piece at the top. When tightening the pressure-releasing cap, the fuselink button will be pressed against the moving contact to ensure a good and stable contact of the fuselink button and the low temperature rise. During the designing, attention has been paid to making suitable selection of the material, size and thickness of the pressure-releasing piece and the choice of the parts such as pressure- releasing caps etc. to make them suit the following requirements:

1) When the interrupting current is 30% less than the rated interrupting current value, the pressure-releasing piece will not be actuated and the tube discharges gas downwards in the one-way manner so as to keep comparatively high pressure within the fuse tube beneficial for extinguishing small short-circuit and over-load currents.

2) When the interrupting current is 30% larger than the rated interrupting current value, the fuse button will shear and break the pressure-releasing piece owing to the action of the pressure in the tube which is relatively great. The button and the pressure-releasing piece will be forced out by the gas current. At this time, the fuse tube discharges gas to both ends so as to enable the high-pressure gas generated under the large short-circuit current to force out of the fuse tube rapidly, thus reducing the mechanical stress applied to the fuse tube when making and breaking the large currents. When using the step-by-step gas discharge construction, the fuse is enabled to increase its rated interrupting current value and to cut off small currents, thereby expanding the range of the interrupting currents and effectively removing the contradiction of the large and small interrupting currents for the arc-extinguishing apparatuses with self gas generation.

The material, diameter and thickness of the pressure-releasing piece should be determined through the designing and interrupting tests. As far as the fuses for various voltage ratings, rated currents and interrupting currents are concerned, the size is different from each other.

In addition, with the step-by-step gas discharge fuses, the fuse tube and top moving contact should be adhered to each other by using epoxy resin and fastened by riveting. This is a technical key point, as in the interrupting instant, the pressure in the tube acts on the top moving contact through the fuselink button, pressure-releasing piece and cap. The force produced causes the top contact to separate from the fuse tube. If the adhesion is not tight enough, the top moving contact is likely to get away from the top end of the fuse tube and bring about interrupting failure. It is shown in experiments that where the adhesive force between the top moving contact and the fuse tube is concerned, tension tests should be made on the mechanical tester. If a two-tons tension strength can be withstood, there will be no removal phenomenon as mentioned above.

3 The Influence of the Size, Position and Installation Manner of the Auxiliary Arc-Extinguishing Tube of the Fuselink.

The construction of the tube fuse with step-by-step gas discharge is conducive to improving the interrupting characteristics. But further steps should be taken to meet the requirements specified in the 4th and 5th interrupting series of the IEC 282-2 standard. We have taken the measure to install an auxiliary small arc-extinguishing tube on the fuse-element. When interrupting a current less than 500A, the small arc-extinguishing tube is mainly used to generate gas for extinguishing the arc and the extinguishing tube in the fuse tube does not produce gas for consumption. When making and breaking the currents larger than 500 A, the small auxiliary arc-extinguishing tube will be burst, and the gas generated in the arc-extinguishing tube will be used for extinguishing the arc. In this case, the small auxiliary arc-extinguishing tube will be broken into pieces and removed out of the fuse tube together with the gas without affecting the rated interrupting currents.

Grouped contrast experiments have been performed in connection with such factors as the material, diameter, wall thickness, and length of the small auxiliary arc-extinguishing tube, the change of the behaviors over the long period of heating of the fuse-element, the manner and location of the installation on the fuse tube, etc. The analyses can be given as follows:

1) Material: As far as the material of the small auxiliary arc-extinguishing tube is concerned, it is required that it produce sufficient amount of gas under the action of the interrupting current less than 500 A so as to be helpful to the extinguishing of small currents. Under the action of large short-circuit currents, it should be broken quickly into pieces without blocking the gas-discharging passage.

During the normal operation, under the action of high temperature, it should not be aged and deteriorated. In addition it should be low in cost and easy in machining.

In the contrast experiments by using materials such as plexiglass, fiber, raw cotton paper soaked with specially prepared arc-extinguishing solution, etc., we have found that the last material is better than the first two materials. Therefore it is employed for the purpose.

2) Size: As the internal diameter of the small auxiliary arc-extinguishing tube is limited by the external diameter of the copper hoop of the fuselink , it should be 1 mm larger. In this way, the copper loop can move freely in the tube. When extinguishing the current that is 2.7 -3.3 times fuse link rating , the small arc-extinguishing tube will stay basically unaffected and when the fuse-element is blown out,the fuse tube will drop properly. If the internal diameter is too small, it will be seized between the two copper hoops of the fuselink so that,after the blowing-out of the fuselink, the fuse tube cannot drop because the small auxiliary arc-extinguishing tube is seized between the two opper hoops. The external diameter of the small auxiliary arc-extinguishing tube should be 2 mm smaller than the internal diameter of the arc-extinguishing tube. In this way, when making and breaking the rated interrupting current, there will be smooth gas discharge. Otherwise, because of the blockage of the gas discharge, there will be fuse tube explosion, or because of the weak perpendicular blowing of the arc, the arc will get out to continue burning as it is blocked in the tube thus leading to the flash along the outer surface of the fuse tube and failing in extinguishing the arc. It is confirmed through experiments that it is desirable to adopt the wall thickness of 1 mm for the small auxiliary arc-extinguishing tube.

Fig 1. The step-by-step gas discharge construction of fuse tube.

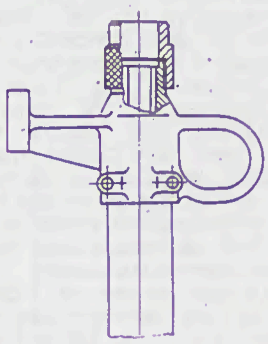

Fig 2. The botton-type fuselink.

The installation position of the small auxiliary arc-extinguishing tube has an important impact on the arc-extinguishing behaviors. The top end of the small auxiliary arc-extinguishing tube shout be fitted closely with the fuselink button so that, when extinguishing the small current, the gas generated will not leak and discharge along the lower end of the small tube to blow the arc in an perpendicular way. In Fig 3 are shown the oscillograms of the 40.5 KV fuse when interrupting the current of 500 A. On the top diagram, as there is a seam between the top end and the fuselink button, when extinguishing the 500-A current, the interrupting fails because the gas generated leaks along the seam. With other conditions unchanged, the mere replacement of the small extinguishing arc-extinguishing tube which is closely fitted to the fuselink button, the interrupting of 500 A current is cleared smoothly (see lower diagram).The length of the small auxiliary arc-extinguishing tube increases with the rise of the rated voltage of the fuse.It has also be found during the interrupting experiments that, on account of the rise of the rated voltage of the fuse, the successful step for extinguishing the small 11.5 KV current fails to function on the 40.5 KV fuse. Clearly,various measures for extinguishing small currents should be taken to fuses with different voltage ratings.

In the experiments it has also been found that that torsion force for the lower fuse to send forth the plate spring also has an impact on the interrupting of the small current. Under its action,the fuselink,after blowing out, will be pushed down rapidly, the speed being particularly sensitive to the interrupting of small currents. the torsion force of the spring has an influence on the time-current characteristics of fuselinks. A suitable torsion force of the soring which is determined through experiments is not only helpful to the interrupting of small currents, but has no influence on the time-current charateristics of fuselinks as well.

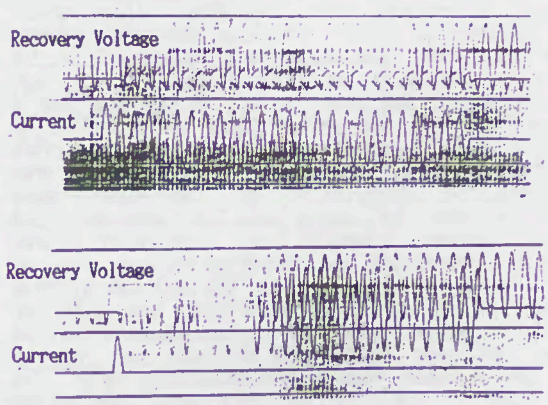

Fig 3. The oscillograms of the 40.5 KV fuse when interrupting the current of 500 A.

4. The Influence of the Position of the Fuse-element in the Fuse Tube

The position of the fuse-element in the fuse has an importance influence on the interrupting behaviors. As far the fuse with single end discharge of gas used abroad is concerned, the fuse-element is close to the buttonhead . Hence, after the fuse-element is blown out, the arc is produced and the gas generated in the arc-extinguishing tube under the action of the arc blows down and in a perpendicularly manner along the tube, which is conductive to the extinguishing of the arc.The fuse tube designed by us is of the type of step-by step discharge of gas. As a result, the fuse-element is not located close to the buttonhead. If the fuse-element is still close to the buttonhead ,the gas generated after the blowing-out will quickly break the pressure-releasing piece and get out of the fuse tube, which is not helpful to the perpendicular blowing and cooling of the arc and often makes the arc get out of the fuse tube and continue the burning.Such a phenomenon has been confirmed through a lot of interrupting experiments. If the fuse-element is situated in the middle position, the arrangement is not good for extinguishing small currents. It has been verified that good results can be obtained when the fuse-element is located at the top end away from the button to some extent. Such a treatment is helpful to the interrupting of both large and small currents. However, the location for 11.5-40.5 KV fuses with various voltage ratings should be different from each other and no identical distance can be used.

5. The Infulence of the Other Factors

When large short-circuit currents are interrupted in the fuse tube, the incandescent gas injected out of the top and lower ends of the fuse tube .the length of the visible light observed by the unaided eye is about 0.3-0.4 m,the top opening being shorter than the lower one and the diameter of the injected gas being 0.2-0.3 m. The injected gas looks like a flame. When the high-speed camera is used to take pictures, the injected gas at high speed from the middle is as long as 1-2 m. In the gas, there are a lot of evaporated metal particles which are produced through the gasification of the melting fuse-element and the tail lead of the fuselink under the action of high temperature of the arc. The length varies with the period of the AC current. It is also dependent on the voltage and interrupting current. This incandescent gas which includes metal vapor will be reflected when meeting an obstacle. As a result, at the top and lower ends, there should be no obstacles within the above mentioned scope. Otherwise, when the gas current injects on to the obstacle, there will be counter injection from it with the result that the outer surface of the fuse tube is coated with a thin metal layer full of a lot of copper vapor, leading to a flash on the outer surface of the fuse tube and re-burning. Therefore, when designing the construction of the fuse, steps must be taken to avoid such a problem. The above factors should be considered when testing, installing and operating the fuse. It has been found through the data analysis of a large number of interrupting experiments that with the 11.5 KV fuse, there cannot be any obstacle in the space 2m away from the top and lower end openings and the distance from the lower end opening of the fuse tube to the ground and other parts such as the support and the case cover of the transformer should be more than 2 m, the distance between two phases should be greater than 0.6 m. With the 40.5 KV fuse, the corresponding distance should be above 3 m and the distance between two phases should also be more than 1 m accordingly.

III The Development of the new type 11.5-40.5 KV Expulsion Fuse

Based on the experiments and investigation of the factors affecting the behaviors of the fuse, we have developed the 11.5-40.5 KV fuses the main technical data of which are shown in Table. 1. The type test of the fuses is done in accordance with the IEC 282-2 standard. Among the new fuses,the RW11-12/100-8 type fuse was tested both in China and the "KEMA" Test Station in Holland resulting in interrupting successfully the 8 KA rated interrupting current (symmetrical) and the 17 A minimum interrupting current. The RW11-12/100-8 type fuse has found wide application in China.The 15 and 27 KV fuses were developed chiefly for meeting the demands of export.

In order to implement the electrification of the rural areas in China, a model plan of the rural substation has been determined as shown in Fig. 4. According to the plan, 40.5 KV fuses will be used in great numbers on the HV side of the 35 KV substations for protecting the transformer from short-circuiting and over-loading. The fuse to be used every year will amount to about 10,000.

Table 1 Technical Parameters of 11.5--40.5 Fuses

Voltage Rating (kV)	Current Rating (A)	Interrupting Ratings (rms amps sym)
12	100	8000
12	200	12500
15	100	10000
27	100	8000
40.5	100	6300
40.5	200	8000

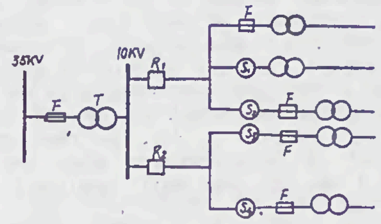

Fig 4. A model plan of the rural substation.

IV A Few Suggestions

Through a great number of interrupting tests,numerous valuable data have been provided for developing new products and at the same time significant information has been accumulated for the revision of the testing standard of "Expulsion and Similar Fuses". It has been confirmed through hundreds of interrupting tests that in accordance with the related regulations for the interrupting tests specified in the IEC 282-2 standard, a fuse must pass 5 series of interrupting tests among which, as far as the first series for testing the rated interrupting current is concerned, the three interrupting tests for installing the fuselink for the minimum rated current are more severe than the three interrupting tests for installing the fuselink for the maximum rated current and accordingly the consumption of the inner arc-extinguishing tube in the fuse tube is larger. This is because under the condition of the same rated interrupting current I, the fuselink for the minimum rated current is blown out earlier than that for the maximum rated current, thus generating the arc. As the tail lead of the fuselink for the small rated current is small in diameter, light in mass and low in heat capacity, under the action of the arc, the section of the tail lead burned out is long; there is a long distance of the arc between the two tail leads; there is a large area of contact between the arc-extinguishing tube and arc; there is a large amount of gas generated and high pressure in the fuse tube. Especially, when a new tube does interrupting for the first time, and the making angle after voltage zero is -5 to +15 (at this time the non-periodical component is maximum) the strength of the fuse tube undergoes the most severe examination. It has been confirmed through the statistical data of hundreds of interrupting tests that during the three interrupting tests for install the fuselink for the minimum rated current, the consumption of the inner arc-extinguishing tube in the fuse tube is 50% larger than that for the three interrupting tests for installing the fuse for the maximum rated current. The RW 11-12/100-8 type fuses were used at the same time;it shows that after the three interrupting tests for installing the 100 A fuselink;the internal diameter of the arc-extinguishing tube increased from 13mm to 14.5mm and that after the three interrupting tests for installing the 5A fuselink, the internal diameter of the arc-extinguishing tube increased from 13mm to 15.3mm. The above conclusion is the same for the arc-extinguishing tubes made of different materials and those made with the same material but produced by different manufacturers. Thus we hold that for the first series of interrupting tests, it is only necessary to make the three interrupting tests for the minimum rated fuselink or to conduct two tests for the minimum rated fuselink and one test for the maximum rated fuselink.

In the four interrupting tests for the second series for 0.7 to 0.8 I (there are two tests for the fuselink for the maximum and minimum currents respectively), the consumption of the fuse tube is still larger than that for the three interrupting tests for installing the fuselink for the minimum rated current so that the test of the electric life of the fuse tube is more severe than the first series. We made several rounds of interrupting tests of fuses. In the first series, the three tests for installing the maximum and minimum rated currents fuselinks respectively all cleared, but in the four tests for the second series of 0.7 - 0.8 I , the first three succeeded in interrupting, whereas the fourth test failed because the diameter of the fuse tube was increased so that the amount of gas generated was not enough. It has also been found in the tests that in the second series of tests, if two tests for installing the fuselink for the maximum rated current was done first and then the two tests for installing the fuselink for the minimum rated current, it was easy to pass the tests. On the contrary, if the two tests for installing the fuselink for the minimum rated current were done first and then the two tests for the maximum fuselink were done,the tests might not be passed. This is due to the fact that when doing the two tests for installing the maximum fuselink ,the consumption of the internal diameter of the arc-extinguishing tube is small;when the minimum fuselink is installed,the internal diameter of the arc extinguishing tube has been increased so that the amount of gas generated and the consumption are less than when doing the test for installing the small fuselink in the new tube but larger than when conducting the test for installing large fuselink; thus the test can be passed successfully. Therefore it is to be suggested that the order for the tests of the second series should be specified clearly as follows: two tests for installing the minimum fuselink and then two tests for installing the maximum fuselink.

Table 2

Parameters	Class	Test series							
		Series 1		Series 2		Series 3		Series 4	Series 5
Power-frequency recovery voltage	1 and 2	Rated voltage $^{+5\%}_{0}$							
Natural frequency of transient recovery voltage (See Note 3)	1	Column (B) of Table IVB						Under consideration	Not applicable
	2	Column (A) of Table IVB							
Amplitude factor (See Note 3)	1	From 1.4 to 1,5							
	2	From 1.3 to 1.4							
R.M.S. symmetrical value of prospective current	1 and 2	$I^{+5\%}_{0}$		From 0.7 I to 0.8 I		From 0.2 I to 0.3 I		From 400 A to 500 A (1) (2)	From 2.7 I_n to 3.3 I_n with a minimum of 15 A (1)
Power-factor	1	Lower than 0.10						From 0.3 to 0.5	From 0.6 to 0.8
	2	Lower than 0.15						From 0.3 to 0.5	From 0.6 to 0.8
Making angle related to voltage zero (degrees)	1 and 2	1st test: −5 to +15 2nd test: 85 to 105 3rd test: 130 to 150		1st test: −5 to +15 2nd test: 85 to 105		For all tests, from 85 to 105		Random timing	
Current rating of fuse-links	1 and 2	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Min.
Number of tests	1 and 2	1	1	1	1	1	1	2	2
Number of fuse-links to be tested for each fuse-carrier	1 and 2	4				2		4	

Notes 1. — If the test involves an operating time appreciably higher than 2 s, the test shall be made with a higher current to obtain an operating time of approximately 2 s.

2\. — If the values are lower than those of series 5, test series 5 need not be made.

3\. — It is expected that service natural frequencies and amplitude factors will usually not exceed the specified values.

In order to reduce the number of tests without lowering the demands for the comprehensive examination of the interrupting behaviors of the fuse, it is to be suggested that the current value, testing order and the number of tests for the interrupting tests for the first and second series should be revised again by the working group for the IEC fuse standard.

It has been found through tests that the fuses which had succeeded in passing the interrupting tests of the first and second series were all able to succeed in passing the tests for the third series for 0.2 - 0.3 I . Since the interrupting testing current value in the third series, is not the critical interrupting current value for the expulsion fuse, it is suggested that in order to reduce the number of interrupting tests the regulations for the tests in the third series should be removed or at least that with the fuse products which have passed all the type tests and finalized the design, the tests for the third series be not needed when the same product is reproduced in a second manufacturer by using the same drawings,technologies and materials.

The purpose of the interrupting tests for the fourth and fifth series is to examine the ability of the fuse to interrupt small accident currents and overload currents.This requirement is indispensable. It is mandatory to conduct the tests for the fourth and fifth series when testing the newly-developed fuses. It has been confirmed from our tests that as the interrupting test for these two series aim mainly at testing the arc-extinguishing behaviors of the auxiliary arc-extinguishing tube,and the inner arc-extinguishing tube in the fuse tube does not act at this time,all the fuses which have succeeded in passing all the interrupting type tests and finalized in the design are able to succeed in passing the interrupting tests for the fourth and fifth series when they are produced by a second manufacturer through the use of the same drawings, technologies and materials. We have done six contrast tests like this fully indicating that when the material, construction, size and installation manner for the small auxiliary arc-extinguishing tube of the fuselink are the same, the products are able to pass the interrupting tests for the fourth and fifth series successfully without any exception. Therefore we should like to suggest that when a second manufacturer makes repeated product, the tests for the fourth and fifth series should not be done.

From hundreds of interrupting tests and investigations and through the analysis of the data of the grouped contrast tests it is concluded that under the condition of ensuring the full and reasonable testing of the interrupting behaviors of the expulsion fuses, it is required to reduce as much as possible the number of unnecessary tests. We should like to make the following suggestions (Table 2) for providing some references for the working group for drafting the IEC fuse standard and revising the IEC 282-2 "expulsion and similar fuses" standard.