October 21, 2010

Jenbo USA, LLC

VIA Federal Express

Dear Mr. Struckmeyer

Division of Materials Safety and State Agreements
Office of Federal and State Materials and Environmental Management
Division of Industrial and Medical Nuclear Safety
Office of Nuclear Materials Safety and Safeguards
Washington, DC 20555-0001

Re: Jenbo USA, LLC
You're Docket No. 30-38293
You're Mail Control No. 022831

By letter of August 9, 2010, the NRC advised, Inc. ("Applicant") that attention is required in respect of certain additional items regarding Applicant's Application for a Material License (exempt distribution license). We wish that the Nuclear Regulatory Commission continue to review our application for exempt distribution of electron tubes (lamps) pursuant to 10 CFR 32.14 (b) (2). We have engaged a local certified health physicist who has explained how to reform our responses.

We understand that, as the initial importer and distributor of devices containing radioactive materials in the United States, we are considered by the NRC to be the initial manufacturer/distributor of the devices, and are responsible for ensuring that the imported devices meet the requirements as described in NRC regulations as authorized by our license.

The additional items referred to in the NRC letter are in regard to (1) specifications for each tube, glass type, thickness, labeling, (2) severe condition information (3) prototype testing (4) qa (5) marking or labeling (6) radiation levels (7) fill quantities of radionuclides (8) qa regarding measurement methods,

I will provide the radiation dose measurements from several tubes in a supplement to this letter.

These additional items are addressed below.

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Question One.

This question pertains to the dimensions and thickness of the bulbs and the material of construction. The bulb is glass quartz; the smallest outer bulb has a radius exceeding 0.5 cm, refer to Table 17. Jenbo Bulbs Specification, for bulb dimensions. The smallest bulb, NSK 150 is about 1 cm across, but this bulb only contains about 300 Bq activity. The specifications for glass tube consists of an inner capsule and outer enclosure (lamp). A total glass thickness specified is minimum of 0.11 centimeter (1.1 mm and 1.5 mm) and 0.15 (outer) is sufficient to attenuate the maximum Kr-85 beta (β) emission to the level specified in 10 CFR 30.15 (8). The inner tube volume ranges from 0.3 ml to 6.5 ml. The 687 kev_{max} β has a continuous slowing down approximation range (CSDA) range (based ICRU Report 37 data) in Pyrex® or borosilicate glass of 330 mg cm^{-2} , dividing by 2,230 mg•$(cm^3)^{-1}$ = a range of 0.148 cm or 1.48mm. The absorber (s) thus exceed the range, and will effectively stop all beta, resulting in a beta dose rate for handling within the Commission's requirements for exempt distribution.

The levels of penetrating radiation from each item containing up to 1 microcurie of Kr-85 material do not exceed 1 millirad per hour at 1 centimeter from any surface when measured through 7 mg •cm^{-2} of absorber. The specific gamma ray constant is 0.044 mR•hr^{-1} per millicurie at 30 cm or 0.039 mR•hr^{-1} per 1 microCurie at 1 cm, without absorber, therefore these bulbs comply with 10 CFR 30.15 (8). The bremstrahlung contribution is negligible[1]. This analytical approach is utilized in NUREG-1717, Systematic Radiological Assessment of Exemptions for Source and Byproduct Materials.

The lamp could contain up to 25 times the specification for this product, and still meet the commission requirements for dose rate at 10 CFR 30.15 (8).

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[1] The radiation yield is 0.00436 for 700 keV electron on glass

Question Two.

The question pertained to containment of byproduct material. The items in question are basically high-tech light bulbs. Light bulbs operate at relatively high temperature and are sealed by hot glass press and / or laser welding methods so none of the filler gases can release from the inner volume. If the seal or weld was inadequate, the lamp would fail from a commercial standpoint, thus containment of a gas required for proper function is essential. The Kr-85 is properly contained and will not release with normal use and handling.

Unlike other products using liquid or solid radioactive material, the light bulbs containing Kr-85 are safe even if they fail because:

- The failure of the container does not leave hazardous residual contamination;
- The dose consequences of inhalation of the material are nil (several orders of magnitude below standards;
- The quantities of byproduct material in individual lamps is about 3% of the limit for exempt distribution;
- The NRC has no restrictions on bulb handling or disposal after the bulb reaches end of useful life;
- Unlike other products, that could continue to function, in a damaged condition, the loss of fill gas is fatal to product functionality.

A review of use and handling of the product identified several scenarios that could cause the lamp to release the contained inventory of radioactive gas. The analysis indicated that the release probability is dependent on what severe condition the product is required to meet and contain the gas. The bulb can overheat, suffer mechanical stress in normal use, be accidently crushed or otherwise stressed, be dropped bare, or be dropped within the full package or partial package. In any event, even catastrophic failure of multiple bulbs in a small confined space does not have a human health risk from the radioactivity released.

Normal usage of these lamps consists of placement in a fixture by hand by the end user and removal when it no longer functions or has reached a declining brightness. The release of the small quantity of Kr-85 contained in these lamps would occur only in the event of the breakage of the quartz bulb. This would not be considered normal usage because users normally take precautions to avoid dropping bulbs. However, in response to your question regarding severe conditions, the most severe condition encountered is the dropping from a height or the malicious destruction of a bulb. In that case, the inner Krypton enclosure and the outer lamp may shatter, allowing the radioactive Krypton-85 gas to escape. Dropping is not considered a normal usage, but may be a credible and severe condition estimated to occur at a frequency of 10^{-4} to 10^{-5} $year^{-1}$. Dropping of the bulb from normal height to floor while in package is not expected to break the bulb, again this is a cost effectiveness function, bulbs must withstand normal transport and distribution stresses.

Assurance of the binding of the Krypton gas in the product is not practicable for the lamp to function. This is because the radioactive material could be released or be removed from the product under the failure of the glass envelope which is the most severe conditions that the product is likely to encounter under everyday normal use and handling. Therefore samples are not subjected to prototype testing to verify containment.

The next most severe condition is overheating caused by overvoltage, misapplication, or other fault. The maximum temperature that the inner receptacle can handle is 2000° F without failure. The maximum estimated temperature the bulb can reach is only 750° F , therefore the inner receptacle will not fail.

The last severe condition of normal use considered in normal use of this product will be encountered by inserting the lamp in the lamp socket by hand. The quartz tube is very stable due to the outer cross section enclosure. The forces ordinarily used in the installation of the electron tube and the manipulation in normal handling, are insufficient to cause breakage of the tube, otherwise we could not profit commercially from distribution of this product. Therefore, there is an infinitesimally low risk that the radioactive material containment envelope will be ruptured in normal inserting the lamp in the lamp socket by hand.

The consequence (radiological) for such a rare event is estimated by our Certified Health Physicist as follows. The dose conversion factor (EPA[2] FGR-11) for Kr-85 is limited as skin-submersion of 1×10^{-3} millirem × hour × picocurie $^{-1}$ × (centimeter^3)$^{-1}$. If a tube containing 1 microcurie ruptures and the volume of mixing in the immediate vicinity of the worker is one cubic meter, then the resulting concentration is 1 picocurie per cubic centimeter. The inhalation dose is then 1×10^{-3} millirem × hour × picocurie $^{-1}$ × (centimeter^3)$^{-1}$ × 1 picocurie per cubic centimeter. Assume the worker inhales this volume for one hour, or the material disperses to negligible concentration after one hour. The dose is then 1×10^{-3} millirem event^{-1}. This corresponds to a lifetime risk[3] of $< 1 \times 10^{-9}$ (stochastic risk) × non-fatal cancer event^{-1} or less than one in a billion.

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2 EPA developed the FGR series based on recommendations developed by the ICRP and published as reports 26 and 30. These reports, while superseded, remain the basis for the DAC and ALI values used by the NRC and published in Appendix B, Table 2 of 10 CFR 20. FGR-11 (EPA 520/1-88-020) is also used by NUREG-1717)

3 Various authoritative sources cite solid cancer risk in the range of ~$1\text{-}8 \times 10^{-4}$ rem^{-1}

Question Three.

The question pertained to prototype testing to ensure containment of byproduct material. The factory performs quality checks on 100% of the bulbs and has a failure return rate of 0.03% or 3 in 10,000. We do not propose to perform additional prototype testing, as the factory has been doing this for over 10 years. In the case of our byproduct material, it is not attached to the lamp, by design, as Kr-85 is a gas. Because you have authorized exempt distribution, it is a rebuttable presumption that the material will eventually be released to the environment without regard to radioactivity. Appendix L of the licensing guidance document[4] states,

Disposal

> *These exempt distribution products may be disposed of in regular waste without regard to their radioactive content providing the customer is not a specific licensee and all radiation symbols have been removed or defaced.*

Therefore, the material is contained, but regular waste disposal could (and likely will eventually) result in complete release of the material, and NRC has no prohibition on crushing the products prior to disposal. All such products will be disposed within one half-life, and the radiological consequence, assuming all bulbs are crushed and the product released, is quite low.

Jenbo USA will test a sample from each lot, approximately 1% of each lot, to verify bulbs are intact, performing properly, and every package will be visually inspected at the USA distributor for shipping damage.

NUREG-1717 assumed that materials going into disposal would not be crushed, however, the radiological consequences of the release of all of Jenbo's production is still low.

Containment is essential for the product to perform its intended function. If the glass is poor quality or the seal fails, the product will not function.

> *Leakage of Kr-85 bulb: "If the shells of the bulbs in which Kr-85 is filled are not damaged, Kr-85 will not leak from the bulbs. Damaged bulbs containing Kr-85 leakage cannot be lit. All of the bulbs manufactured by Taicang Jieenbao Lighting Equipment Co., Ltd. For Jenbo USA undergo a 10-minute bulb aging test. This test is strictly administered after Kr-85 filling to get rid of the bulbs which cannot be lit. In addition, all bulbs undergo visual quality inspection prior to shipment to ensure uniform quality."*

The sealing process is described in Table 5. SEALING PROCESS FOR JENBO BULBS. The testing performed in China is described in attachment Table 7. Preventing Leakage of Kr-85 from Bulb Products

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[4] NUREG-1556 Volume 8

Question Four.

Description of quality assurance in production lots. The product is required to maintain integrity of the seal over the useful life of the bulb. Because accelerated stress testing is not practicable, Jenbo USA proposes to monitor bulb performance by monitoring returns and failures.

In response to your question concerning how we will verify that each product contains no more than the quantity of byproduct material specified for that product, we will use the manufacturers functionality test (*10-minute bulb aging test*), the automated pressure filling system (see Table 3. Fill Gas process for Jenbo Bulbs and Table 4. Leak Detection), the gas supplier certification of the activity of Kr-85 in the gas blend, and the fact that overpressure/overfill will degrade bulb performance. Any tube determined to produce a sub-par output is rejected by the factory.

Small variations in filling pressure and volume with respect to different lamp types are of minor importance because activity is in all cases well below the limit. As an attachment you will find a technical drawing of a typical lamp showing the main gas containment vessel for the tube.

QA Process includes the burn-in as follows:

> *"After the filling process the lamp voltages of all lamps are monitored. A burner which is not inside the specification is regarded as a possible leaker and is discarded. After putting the socket on the burner all lamps are burnt in. A lamp passing this test is considered to be o.k. because a leaking lamp would not start up."*

Question Five

This question pertains to Marking of individual lamps.

Every lamp inner carton has the KR85 label. We also label the outer carton as well and include a package insert with each shipment. The label statement is shown below as Table 1. Bulbs Label Statement. Each lamp containing Kr-85 will be separately packaged. The package for each lamp containing Kr-85 will bear the markings i.e. the name of the initial importer and distributor, and "Kr-85." Applicant does not propose to affix labels containing the name of the initial importer and identification of the byproduct material directly to the lamps. The lamps are too small and/or become too hot when in use for it to be practical to affix labels directly to the lamps. By separately packaging each lamp, the information required is presented to the lamp user.

Because the bulbs operate in a very hot environment, adhesive labels will not be placed on the lamp. A sample package insert placed on the inner packaging will read as follows.

Table 1. Bulbs Label Statement

a. All bulb products are labeled "Contains Krypton-85 gas"
b. All bulb products carry the label "Manufactured by Taicang Jieenbao Lighting Equipment Co., Ltd. For Jenbo USA" or "Jenbo USA"

Question Six

This question pertains to compliance with radiation level limits on each bulb. The rule 32.14 (b) (7) asks the applicant submits sufficient information regarding the product pertinent to evaluation of the potential radiation exposure, including:

(7) For products for which limits on levels of radiation are specified in § 30.15 of this chapter, the radiation level and the method of measurement;

The radiation level for a 1 microcurie fill is determined by calculation to be 0.039 mR·hr-1 per 1 microCurie at 1 cm, without absorber , this method was used by NUREG-1717 and our calculations agree with that NRC publication. This assumes a point source and no glass attenuation of the photon. Radiation level tests should not be required for demonstration of compliance with the rule, based on NUREG-1556 Volume 8, page 9-4, however, Jenbo USA shall commit to a test, to measure surface dose rate in contact with the tube. Refer to

Table 12. Radiation Level Measurement Information, for results of measurements. The calculated dose rates are a fraction of the limit 1 millirad per hour at 1 centimeter from any surface. The measurements will confirm that the dose rates meet the standard.

Manufacture's process confirms that the tube is not overfilled with radioactive gas or that the product manufactures contains in excess of 30 microcuries of radioactive Krypton. The factory performs the functionality tests which involve testing each tube or lamp to confirm that the lamp works and that the light output is within the range known for that tube or lamp for which the activity fill has been determined. Nonworking product, above par output or below par output are considered indicative of excessively filled or leaking tubes. Testing in this fashion is as described in based on NUREG-1556 Volume 8, page 9-4.

The quantity of Kr-85 in the arc tube is a function of the specific activity of the filling gas and volume of the arc tube. Each tank of the Argon-Krypton-85 mixture received from the supplier comes with a certification concerning the Krypton-85 concentration.

The tubes do not require additional radiation measurement to ensure compliance with the standard, based on calculation and geometry, if the specification fill is met, the radiation level will be in compliance. The fill could be 25 times the specification and still be in compliance, however, this is not a credible occurrence.

Bulbs contain as follows, the highest bulb is nominally 0.15 microcurie

Table 2. Bulbs Activity Contained and Calculated Dose Rate (1 cm)

bulb	Bq	uci	mR/hr
NSK150	318	0.008595	0.000335
NSK250	881	0.023811	0.000929
NSK250/2	881	0.023811	0.000929
NSK300	980	0.026486	0.001033
NSK575	2936	0.079351	0.003095

NSK575/2	2936	0.079351	0.003095
NSK400	881	0.023811	0.000929
NSK575HR	980	0.026486	0.001033
NSK1200SA	4078	0.110216	0.004298
NSK1200	4078	0.110216	0.004298
MHK300	980	0.026486	0.001033
MHK575	2447	0.066135	0.002579
MHK700	1174	0.03173	0.001237
MHK575/2	2447	0.066135	0.002579
MHK1200DX	3426	0.092595	0.003611
MHK1200	5303	0.143324	0.00559

Question Seven

This question pertains to assurance that the individual bulbs do not contain more than 30 microcuries of Kr-85. Jenbo purchases a mixture of Argon and Kr-85 from a Chinese vendor, and the vendor certifies the gas mixture is traceable to the China Institute of Atomic Energy. Refer to Table 14. Translation of Supplier Certifying Agency, Table 16. Calibration Certificate for Pressure Guage, and Table 10. Bulb Pressure and Volume for details. Arc tubes for lamps have different internal volumes , however the maximum volume is 6 ml. The quantity of Kr-85 in any arc tube is a function of the internal volume of the arc tube and the pressure of the gas mixture with which the tube is filled. The filling of arc tubes with the gas mixture is computer controlled to assure uniformity of desired pressure in the arc tube. The amount of Kr-85 contained in any arc tube can be determined with certainty by calculation based on proportionate quantity of Kr-85 in the gas mixture, volume of the arc tube and computer controlled fill pressure.

Fill pressure of arc tubes is in a range of 160 Pa depending on wattage and geometry, and is checked by automated equipment. (1 Pa ~ 9.87×10^{-6} atm or 7.5028×10^{-3} mm Hg)

See Table 10. Bulb Pressure and Volume for the details for each tube and Table 14. for further details.

Jenbo purchases a gas mixture which includes Kr-85. The gas mixture is purchased in cylinders. The vendor is a local (Chinese) company, and the vendor certifies the concentration of each gas in the gas mixture. The inner lamp bulbs are filled with the gas mixture. The filling pressure of the gas mixture for each bottle is controlled by a pressure controller. These pressure controllers are calibrated on site every year using a calibration gauge which is calibrated every 2.

By maintaining constancy of the desired filling pressure for each bulb, it can be determined by calculation that the amount of Kr-85 contained in any bulb is under 1 microCi.

Small variations in filling pressure and volume with respect to different lamp types are of minor importance because activity is in all cases well below the limit. As an attachment Table 17. Jenbo Bulbs Specification, you will find a technical drawing of a typical lamp showing the main gas containment vessel for the tube.

Because the amount of Kr-85 used in the subject lamps is too small to be accurately measured by common radiation detection equipment for purpose of quality assurance (0.039 mR/hr per 1 microCi at 1 cm), the only practical method of controlling the amount of the Kr-85 in the lamps is as described below.

The Argon-Kr-85 gas mixture is certified by the manufacturer as to the concentration of Kr-85. The volume of glass tube to be filled depends on the inside diameter of the tube and the fill length as determined by the pinching distance, and is six (6) milliliters or less.

Even a large out of tolerance would not result in non compliance as our bulbs are designed to hold 1 microcurie Kr-85 and the standard is 30 microcurie.

Furthermore,

The pressure of the Argon/Kr-85 gas mixture in the supply tank is regulated to provide the desired quantity of the mixture in the glass tube for the lamp model being manufactured

- The gas comes from a certified supplier and is assayed, Krypton-85 is quite expensive, therefore the supplier has a good incentive to provide a correct gas blend.
- If the gas pressure in the lamp tube were to be significantly out of specification, there would be a problem with the ignition of the finished lamp and Quality Control would reject the lamp
- If the volume of the lamp pinch were to be out of specification, the lamp voltage would not be in the right range, and therefore the lamp would not operate properly and factory Quality Control would reject the lamp;
- No lamp is designed to be manufactured containing more than 1 microcurie of Kr-85.

Question Eight.

This question pertains to quality assurance.

Refer to Table 13. Quality Assurance Test Methodology for a translation of the factory quality assurance for inner bulb insertion.

The bulbs are inspected at the manufacturer and each bulb undergoes a 2-hour burn-in at the factory as requested by Jenbo-USA. The lamp has to function and not leak in order for the manufacturer to stay in business, thus quality is assured. QC is described in several tables. In the middle of the lamp, a quartz tube is placed with current carrying lead. During production, the ends of quartz tube are heated to the melting temperature and then the glass tube is pinched to effectively seal the ends.

This standard technique of pinching glass is used for millions of general lighting lamps per year and for our manufacturer, this process is well known. The external lead wires are welded to electrical contact metals.

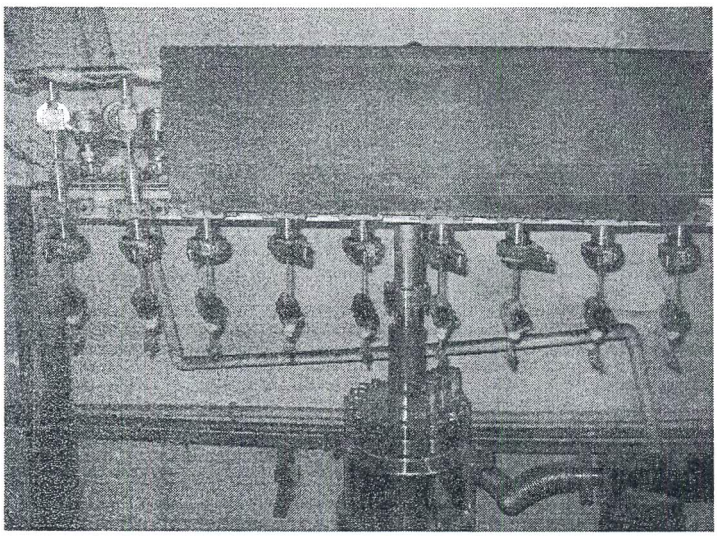
The method of containment is accomplished by sealing the quartz glass by melting. Softening of the seal requires high temperatures, but the operational temperature of the bulb is well below this softening temperature and is never approached, as previously stated.

The quartz vessel is below atmospheric pressure, at room temperature, and by imperfect sealing would result in a filling up of the arc tube with air. The Kr-85 will remain in the vessel. Besides this, such a leakage could be detected very easily because the presence of a small amount of air disables ignition capability and is detected during production controls.

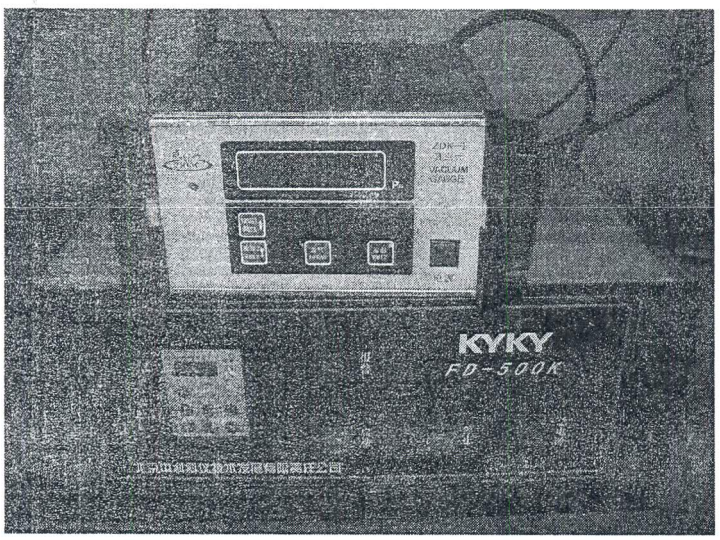
The burner is enclosed in a lamp that is also sealed, as an additional barrier to leakage.

Attachments

Table 3. Fill Gas process for Jenbo Bulbs

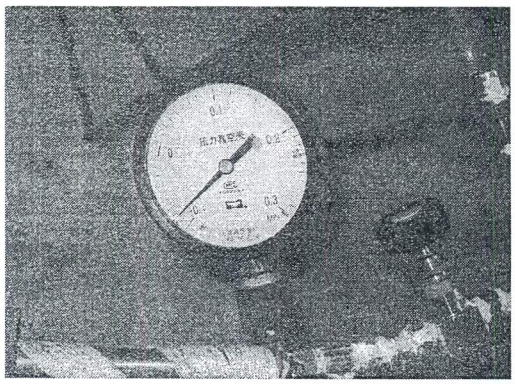


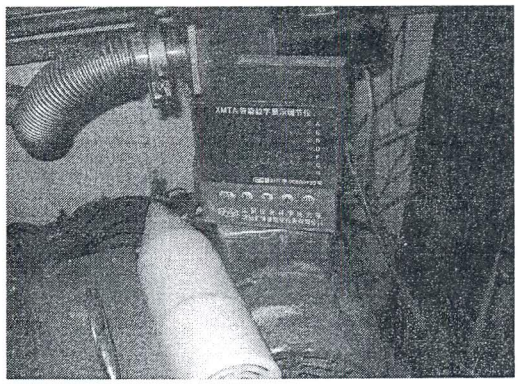
把灯泡接到排气车上，整个充气管道是密封的。(The bulbs prepared to be filled with gas)



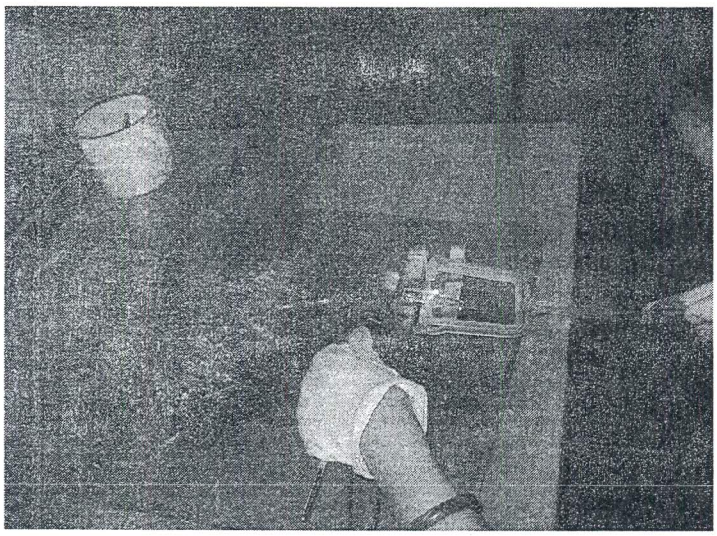
检查真空计是否正常，一般要求仪器显示在-
3帕是为正常真空度，没有漏气，可以开始工作。如果是-1帕和-2帕是不正常的，表示有漏气，。

This machine does 1. Check to make sure the bulb is vacuumed. 2. If the gauge showed -3pa that should be a normal operation status. If the machine shows it's -1 or -2 pa then there is leakage.

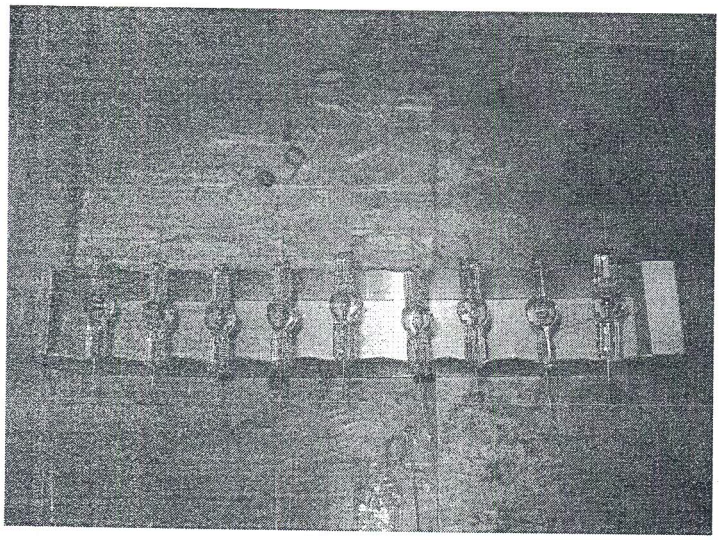




充气，以这个灯250W为例，要求是冲气160毛，这时压力表会显示读数，同时数字显示调节仪也会显示读数. Fill process. Ex is to fill this bulb NSK250 must be filled to 160 Pa when pressure gauge will show readings, and digital display regulator will display readings

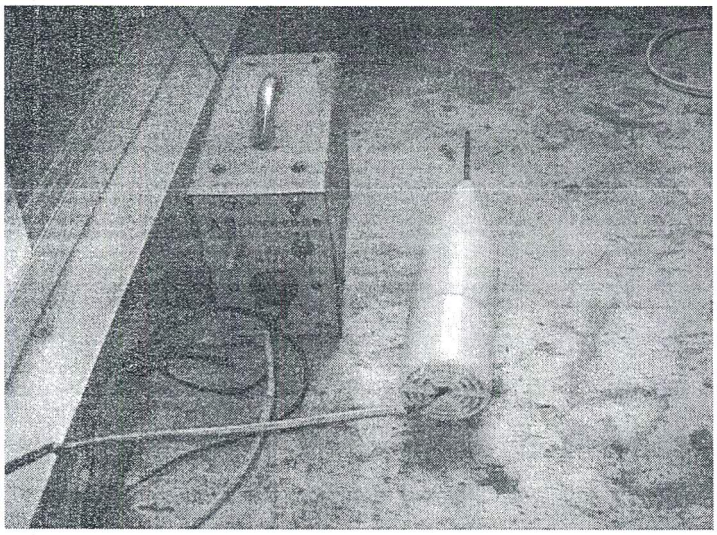


完成充气，把灯泡从排气车上割下来，割掉排气梗，把排气口压平。After gas is filled, they will remove the exhaust tip stem and level the tip

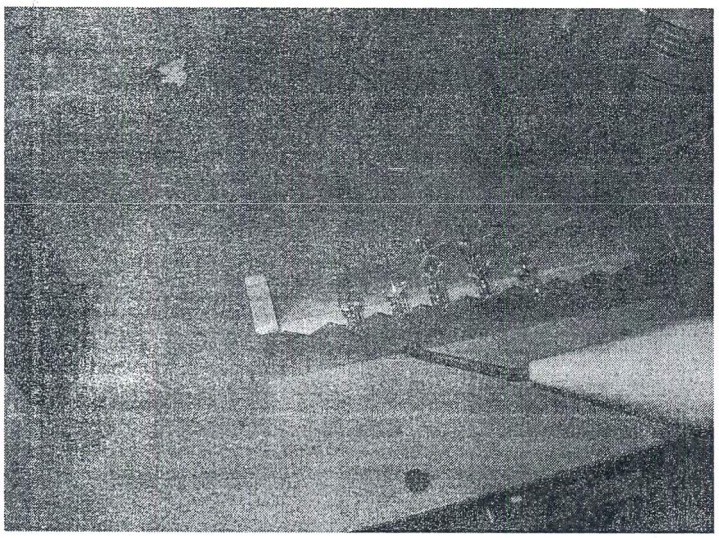


完成充气过程。。(Completed fill process)

Table 4. Leak Detection



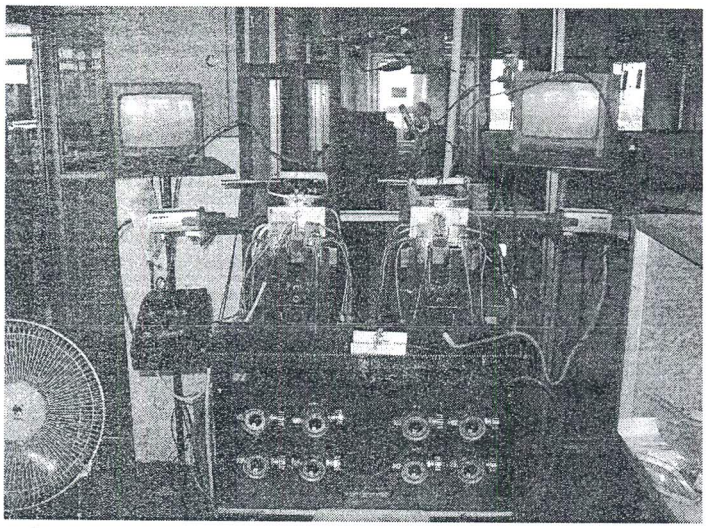
检漏器，检查泡壳是否漏气。Leak detector machine, inspection tool for leakage)



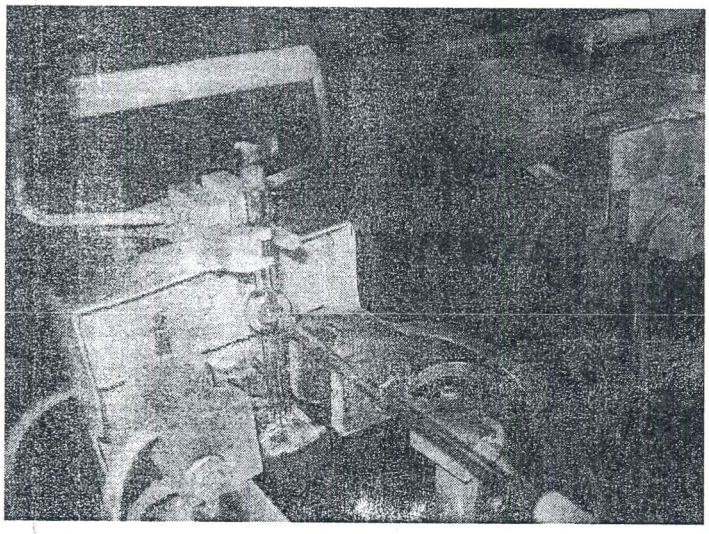
泡壳成型，检查是否漏气，正常情况下灯泡是蓝颜色，如果漏气泡壳颜色是红色的。

Lead checkage. If there is 0 leakage then the color will emit blue, if the leakage of the capsule color is red and therefore discarded.

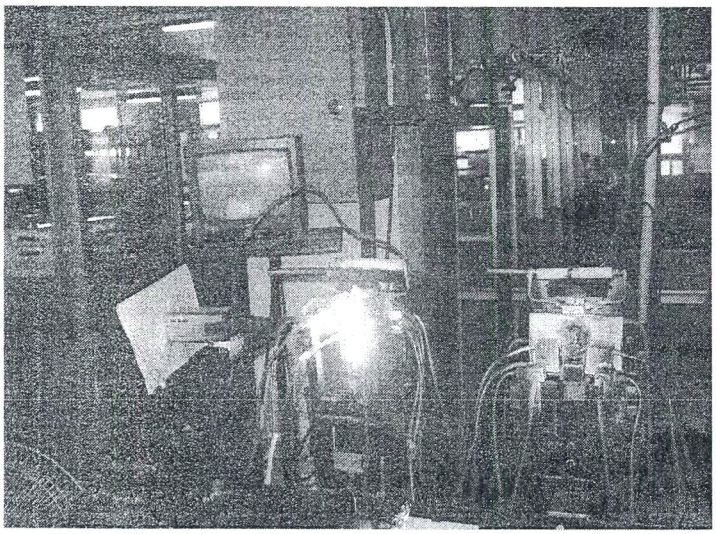
Table 5. SEALING PROCESS FOR JENBO BULBS



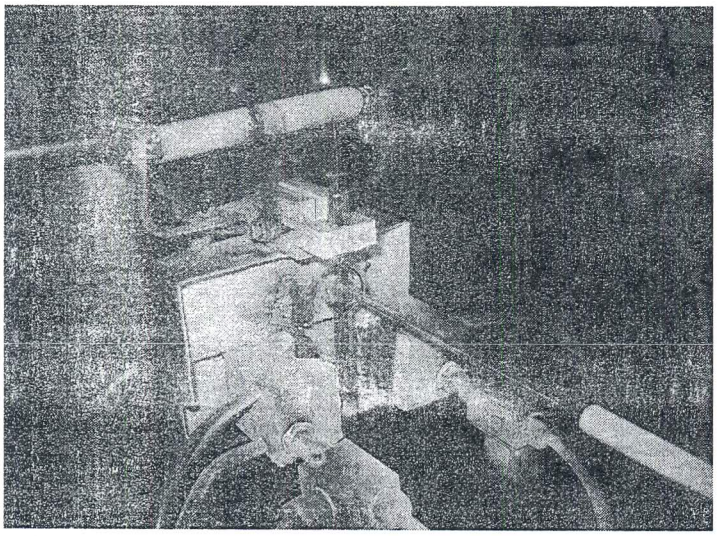
压封机 左边是压封泡壳的第一头的，右边是泡壳的第二头的。(Pressure seal machine. There are left and right sides to seal each side of a dual sided bulb (MHK series) (NSK series will only use one seal)



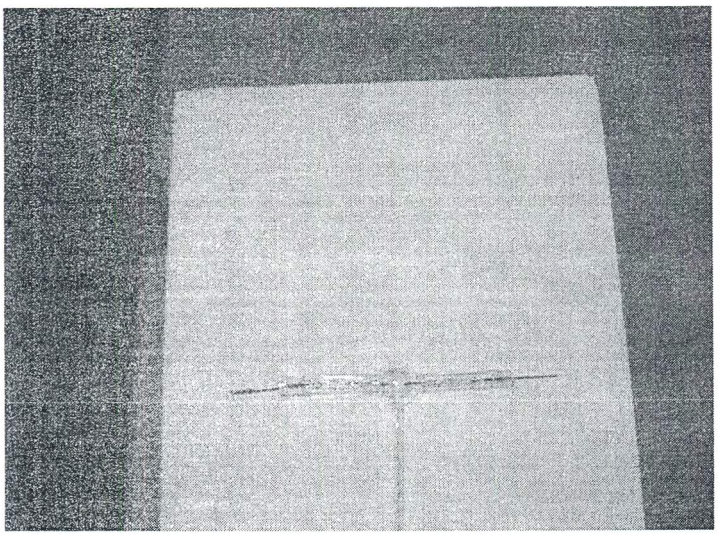
加入电极，开始泡壳第一头的压封。(Joined the electrode to start the first head of the pressure bubble shell closure.)



泡壳第一头压封过程中。Shell of the first head pressure seal process



第二头压封的步骤同第一头是一样的，这是第二头压封完成的图片，这样整个泡壳就完成了。The second step in the first pressure seal with the first head is the same, this is the second pressure seal to complete the picture first, so that the foam shell is complete.



泡壳密封成型图 Final image of sealed.

Table 6. Kr85 Activity, Leakage & Waste Handling

For Jenbo USA

In order to improve the starting performance and quality of discharge lamps, Taicang Jieenbao Lighting Equipment Co., Ltd. utilizes specialized technology to fill our bulb products with a small quantity of radioactive gas (Kr85).

After being mixed with Ar and with the help of a special gas-filling device, Kr85 is filled into each bulb through a sealed tube.

Activity of Kr85 in each bulb, refer to Table 11. Fill Activity:

Leakage of Kr-85 bulb:

If the shells of the bulbs in which Kr-85 is filled are not damaged, Kr-85 will not leak from the bulbs. Damaged bulbs containing Kr-85 leakage cannot be lit. All of the bulbs manufactured by Taicang Jieenbao Lighting Equipment Co., Ltd. For Jenbo USA undergo a 10-minute bulb aging test. This test is strictly administered after Kr-85 filling to get rid of the bulbs which cannot be lit. In addition, all bulbs undergo visual quality inspection prior to shipment to ensure uniform quality.

Table 7. Preventing Leakage of Kr-85 from Bulb Products& Quality Control Measures

In Light bulb is inside the bubble (burner) and is surrounded by an inner and outer shell (outer bulb).
- If the inner shell is not damaged, Kr85 will not be disturbed.
- Kr85 will only leak out if the inner shell is broken.
- All of our light bulbs use equipment housings (glass enclosures) that are sealed for protection, so if the light bulbs should burst, the device will be well-sealed.
- If a light bulb burst occurs, there is no adverse effect to the environment or to the handler due to the extremely low level of Kr85 contained in each bulb.
- The fill volume of each bulb Kr85 is less than <10000Bq.

Figure 1. Light Bulb Design

, the light bulb is inside the bubble (burner) and is surrounded by an inner and outer shell (outer bulb).
- If the inner shell is not damaged, Kr85 will not be disturbed.
- Kr85 will only leak out if the inner shell is broken.
- All of our light bulbs use equipment housings (glass enclosures) that are sealed for protection, so if the light bulbs should burst, the device will be well-sealed.
- If a light bulb burst occurs, there is no adverse effect to the environment or to the handler due to the extremely low level of Kr85 contained in each bulb.

Table 8. Preventing Leakage of Kr-85 from Bulb Products

Light bulb is inside the bubble (burner) and is surrounded by an inner and outer shell (outer bulb).
- If the inner shell is not damaged, Kr85 will not be disturbed.
- Kr85 will only leak out if the inner shell is broken.
- All of our light bulbs use equipment housings (glass enclosures) that are sealed for protection, so if the light bulbs should burst, the device will be well-sealed.
- If a light bulb burst occurs, there is no adverse effect to the environment or to the handler due to the extremely low level of Kr85 contained in each bulb.
- The fill volume of each bulb Kr85 is less than <10000Bq.

Figure 1. Light Bulb Design

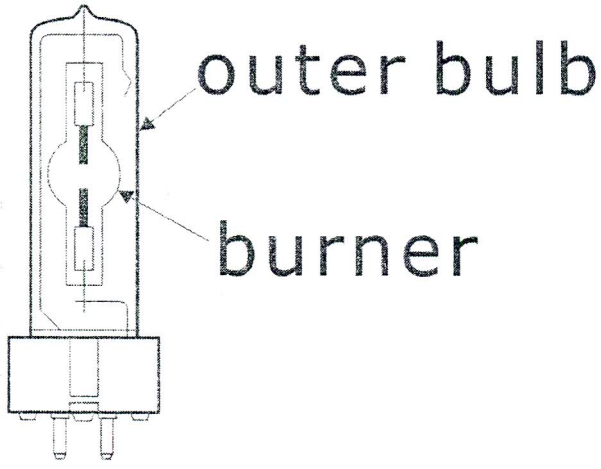
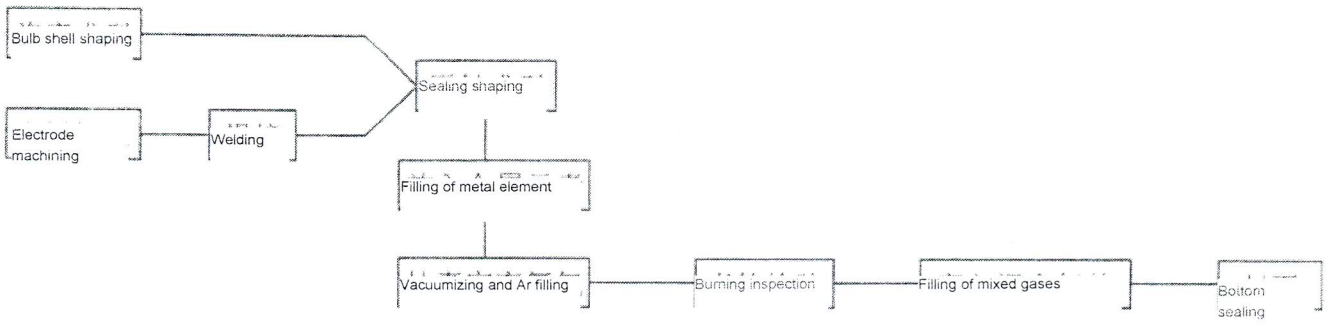


Figure 2. Manufacturing process of **NSK & MHK** high-intensity discharge lamps:



Radioactive element ^{85}Kr is used during filling of mixed gases. Here is a schematic diagram of the gas filling system.

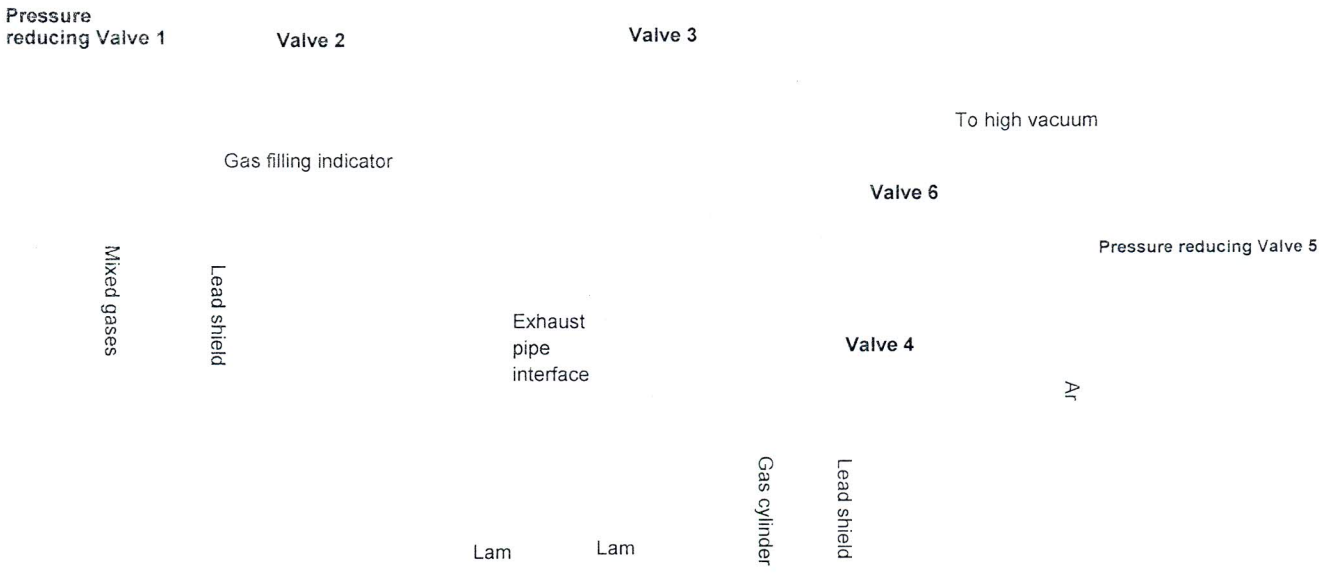


Figure 3. Here is a schematic diagram of the gas filling system.

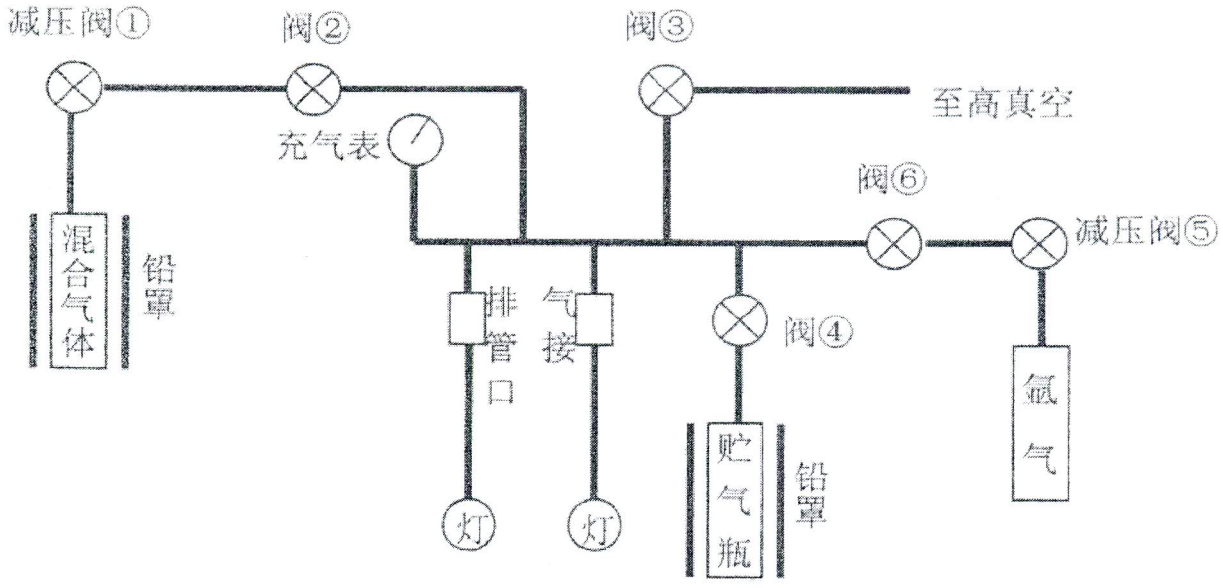


Table 9. Steps for the Filling of Mixed Gases:

1. Inspect if all valves are closed.
2. Insert the quartz exhaust pipe of which one end is completely blocked into the exhaust pipe interface.
3. Vacuumize the vacuum system to be high vacuum (above 10^{-4}pa).
4. Open valves 2, 3, 4 and 6. Vacuumize the pipeline, the quartz exhaust pipe and the gas cylinder to the high vacuum setting and inspect and make sure there are no systems suffering from gas leakage.
5. Close valves 3 and 6 (no system vacuumizing) and open valve 5 to reduce pressure and fill Ar. Open valve 6 to fill about 200 torr of Ar and close it finally.
6. Open valve 3 to extract the Ar completely and to be high vacuum (system cleaning). Repeat steps 4 to 6 twice. Finally, close valve 3 to fill about 600 torr of net Ar (the filling is controlled by valve 6).
7. Close valves 2 and 4 and keep valve 6 closed.
8. Disconnect the exhaust pipe of the plug and insert it into the tube waiting for filling of mixed gases.
9. Open valves 2, 3 and 4 and vacuumize the tube to be high vacuum. Close valves 2 and 4 half an hour later and start filling of mixed gases.
10. Close valve 3 and open pressure reducing valve 1.
11. Fill the mixed gases. Open solenoid valve 2 to control the filling of some fixed gases and close it finally. By then, mixed gas has been filled into the tube.
12. Take down the tube after sealing it with fire head (将灯管用火头封割取下灯管).
13. Close valve 1 and open valve 2 (if it is necessary to work on, this step is unnecessary).
14. Open valve 4 and freeze with liquid nitrogen for 20 minutes. By now, all 85Kr and a majority of Ar

have been frozen into the gas cylinder. The figure on the gas filling indicator will drop till the limit is reached.

15. Close valve 4 and take down the liquid nitrogen device. Open valve 3 and vacuumize it to be high vacuum.
16. Close valve 3, fill 600 torr of net Ar and finally close valve 6.
17. Close valves 1 and 5 before finishing the work.
18. Close the vacuum extraction system.

Table 10. Bulb Pressure and Volume Information

灯的容积和充气毛数及Kr85含量表

Bulb Type	Gas Volume (ml)	Pressure fill in (Z_{he}毛) (Pa) measurement
NSK150W	0.3	130
NSK250W	0.9	120
NSK250/2W	0.9	120
NSK300W	1	120
NSK575W	3	120
NSK400W	0.9	120
NSK575HR	1	120
NSK1200SA	5	100
MHK700W	1.2	100
MHK300W	1	120
MHK575W	2.5	120
MHK1200/DX	3.5	120
MHK1200W	6.5	100

Table 11. Fill Activity

Specification	Activity of Kr85 (Bq)
NSK 150W	318
NSK 250W NSK 250W/2	881
NSK 575W NSK 575W/2	2936
NSK 1200W	4078
MHK 575W MHK 575W/2	2447
MHK 1200W DX	3426
MHK 1200W MHK 1200W/2	5303

Report of Radiation Test
Jenbo USA
Berkeley, California

T1.12

Radiation Level[1] Measurement[2] Information

Bulb Type	Kr-85 Content (Bq)	Radiation Exposure[3] Rate (micro-roentgen hr-1)
NSK150W	318	< 1
NSK250W	881	< 1
NSK250/2W	881	< 1
NSK300/2W	980	< 1
NSK575W	2936	< 1
NSK575/2W	2936	< 1
NSK400W	881	< 1
NSK575HR	980	< 1
NSK1200	4078	< 1
MHK700W	1174	< 1
MHK300W	980	< 1
MHK575W	2447	< 1
MHK575/2W	2447	< 1
MHK1200/DX	3426	< 1
MHK1200/SA	3426	< 1
MHK1200W	5303	< 1

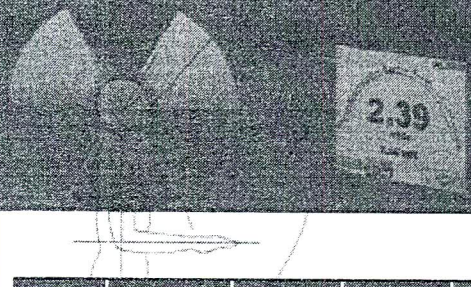
Conrad I. Sherman, CHP
Bay Pacific Health Service
October 29, 2010

Conrad I Sherman

1 Ludlum 44-38 probe, serial PR286630 open-window (without energy compensating filter), Ludlum ratemeter and probe were calibrated (Ludlum) within past 12 months (Feb 5, 2010), bulb in contact with detector.

2 Calculated exposure rates range from <1 to about 3 micro-R per hour

3 1 micro-Roentgen per hour is equivalent to approximately 0.001 millirad per hour



Detectors

Beta-Gamma

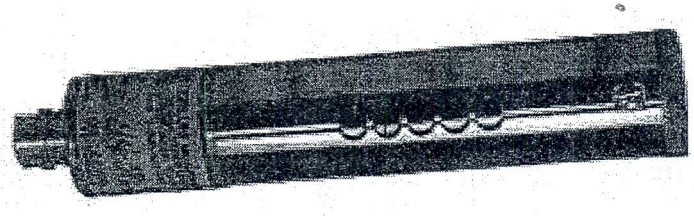
Model	Application	Detector Type	Area (Active/ Open)	Window	Efficiency (4π)	Bkg	Sensitivity	Dead Time	Energy Response	Beta Cut-off	Operating Voltage Vdc	Part Number
44-6	exposure measurements	GM		30-45 mg/ cm^2 stainless steel wall, housing: 1000 mg/ cm^2	closed 17%-^{60}Co 0.35%-^{137}Cs open 19%-^{60}Co 0.50%-^{137}Cs	closed 20 cpm, open 25 cpm	1200 cpm/mR/hr (^{137}Cs)	95 µsec	energy dependent	≈ 200 keV (window open)	900	47-1535
44-38	dose rate measurements	GM, energy compensated		30-45 mg/ cm^2 stainless steel wall, housing: aluminum	closed 18%-^{60}Co 0.37%-^{137}Cs open 21%-^{60}Co 0.48%-^{137}Cs	closed: 20 cpm, open: 25 cpm	1200 cpm/mR/hr (^{137}Cs)	95 µsec	± 15% from 50 keV-1.25 MeV	≈ 200 keV (window open)	900	47-1588
44-92	contamination survey	Sealed gas proportional, Xenon	169 cm^2/ 140 cm^2	6 mg/cm^2 aluminized Mylar	10%-^{14}C 13%-^{99}Tc 24%-^{36}Cl 26%-^{90}Sr/^{90}Y 3%-^{129}I 1.6%-^{57}Co 1.2%-^{55}Fe 10%-^{239}Pu	700 cpm	36,000 cpm/mR/hr (^{60}Co)	30 µsec			1350-1600	47-2362
44-110	tritium surface contamination	gas flow, P-10	126 cm^2/ 100 cm^2	windowless	25%-^{3}H	400 cpm	N/A	N/A			1700	47-2585
44-21	low energy beta-gamma	1 in. dia x 1 mm thick NaI adhered to a 0.001 in. thick plastic scintillator	5.1 cm^2/ 5.1 cm^2	3.4 mg/cm^2	19%-^{129}I 5%-^{14}C 28%-^{32}P	450 cpm	20 kcpm/ mR/hr ^{137}Cs	10-15 µsec	energy dependent		500-1200	47-1560
44-98	surveying, sample counting	1 in. dia x 1 mm thick BGO	5 cm^2/ 5 cm^2	1.2 mg/cm^2	10%-^{14}C 20%-^{129}I	650 cpm		10-15 µsec			500-1200	47-2465
44-172	beta & low energy gamma	1 in. dia x 1 mm thick YSO	5 cm^2/ 5 cm^2	1.2 mg/cm^2	25%–^{129}I 8%–^{14}C 7%–^{55}Fe ^{137}Cs–2.5% ^{241}Am–11.7% ^{57}Co–7.4%	300 cpm		10-15 µsec	5-145 keV		500-1200	47-3543

Introduction

The Model 44-38 is a Geiger-Mueller (G-M) beta/gamma survey detector that is intended to be used with any portable ratemeter or scaler instrument that provides 850-1200 volts with an input sensitivity of 30 ± 10 mV.

The typical gamma exposure rate sensitivity is 1200 cpm per mR/hr. The response range of the Model 44-38 is nominally linear, (within 10%) up to 50 mR/hr without instrument dead time correction and up to 500 mR/hr with dead time correction. Dead time is typically 95 microseconds.

The detector also incorporates a rotary shield, which when opened, allows the detection of beta radiation for energies above approximately 200 keV. If the meterface of the connected electronics is in exposure rate, like mR/hr, then be aware that the beta contribution does not directly correlate to exposure rate. For example, if the meter increases by 2 mR/hr when the shield is opened, it is not correct to say that the exposure rate has increased by 2 mR/hr.



Model 44-38

Note:

Proper gamma exposure rate readings can only be obtained with the shield in the *closed* position.

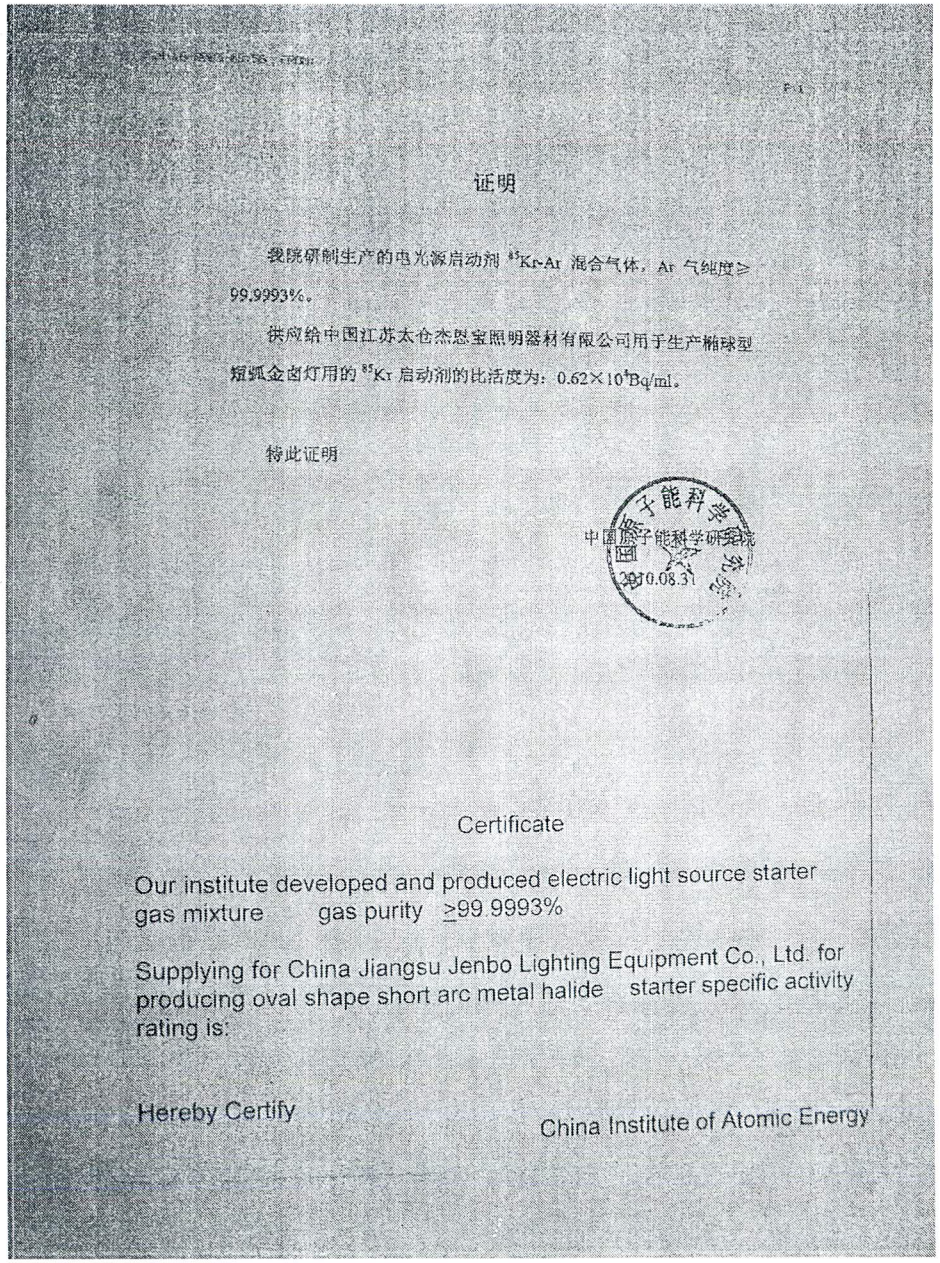
Table 13. Quality Assurance Test Methodology

The following is the factory quality assurance test methodology for inner bulb insertion:

- *Each unit post insertion should have a smooth translucent blister with no obvious lesion spots and should display a smooth exhaust.*
- *Each bulb's plate and sealing surface is inspected to be on the same plane as a straight line, using a linear tool to ensure that there are no skews, or spots.*
- *Sealed end is individually inspected for fragments and or splits. It's then tested for leakage by burning the bulb for 10min. Leakage will reveal a faulty bulb which is then discarded.*
- *Each bulb is inspected for molybdenum film formation, oxidation, and any sealing leaks on the electrode. In an film formation or oxidation builds the bulb is removed from production. Sealing leads on the electrode are exposed during the bulb burn in test in the prior bullet pt.*

Those tested as leaking will be discarded in China.

Table 14. Translation of Supplier Certifying Agency



证明

我院研制生产的电光源启动剂 ^{85}Kr-Ar 混合气体，Ar 气纯度≥99.9993%。

供应给中国江苏太仓杰恩宝照明器材有限公司用于生产椭球型短弧金卤灯用的 ^{85}Kr 启动剂的比活度为：$0.62\times10^{6}Bq/ml$。

特此证明

中国原子能科学研究院
2010.08.31

Certificate

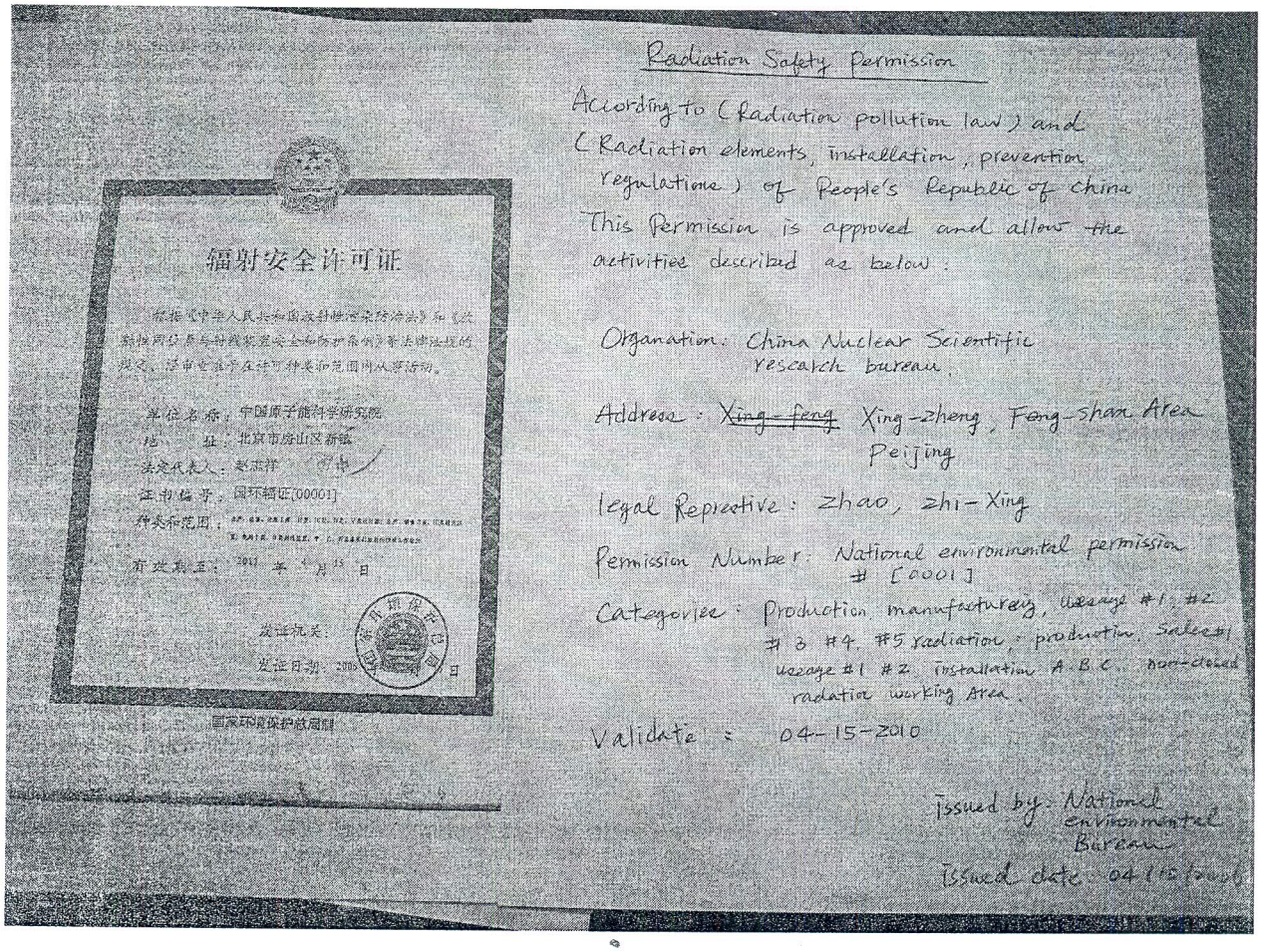
Our institute developed and produced electric light source starter gas mixture gas purity ≥99.9993%

Supplying for China Jiangsu Jenbo Lighting Equipment Co., Ltd. for producing oval shape short arc metal halide starter specific activity rating is:

Hereby Certify

China Institute of Atomic Energy

Table 15. Translation of License



辐射安全许可证

根据《中华人民共和国放射性污染防治法》和《放射性同位素与射线装置安全和防护条例》等法律法规的规定，经审查准予在许可种类和范围内从事活动。

单位名称：中国原子能科学研究院

地　　址：北京市房山区新镇

法定代表人：赵志祥

证书编号：国环辐证[00001]

种类和范围：

有效期至：2011 年 4 月 15 日

发证机关：

发证日期：2006 年 4 月 15 日

国家环境保护总局制

Radiation Safety Permission

According to (Radiation pollution law) and (Radiation elements, installation, prevention regulations) of People's Republic of china This Permission is approved and allow the activities described as below:

Organation: China Nuclear Scientific research bureau.

Address: ~~Xing-feng~~ Xing-zheng, Feng-shan Area Peijing

legal Represtive: zhao, zhi-Xing

Permission Number: National environmental permission # [0001]

Categories: Production manufacturing, usage #1, #2 #3 #4, #5 radiation, production, Sales #1 usage #1 #2 installation A.B.C. non-closed radation working Area.

Validate: 04-15-2010

Issued by: National environmental Bureau

Issued date: 04/15/2006

Table 16. Calibration Certificate for Pressure Guage

太仓市计量测试检定所
TaiCang Institute of Measurement and Testing

检定证书编号：
Verification certificate No.

国家法定计量检定机构计量授权证书号：（苏）法计（2004）004号
The number of the Certificate of Metrological Authorization to The Legal Metrological Verification Institution is No. (2004)004

中国实验室国家认可委员会（CNAL）实验室认可证书号：NO. L0594
The number of the certificate accredited by CNAL is No.L0594

本次检定所依据的技术规范（代号、名称）：
Reference documents for the verification (code, name)

本次检定所使用的主要计量标准器具：
Main measurement standards used in this verification

名称/型号 Name/Model	器具编号 Number	证书编号/有效期限 Certificate No/Due date	测量范围/准确度 Measuring range/accuracy
		404507/20100706	
		460506/20110315	

以上计量标准器具的量值溯源至国家基准。
Quantity values of above measurement standards used in this calibration are traced to those of the national primary standard in the P.R. china

检定地点及环境条件：
Location and environmental condition for the verification

地点：
Location

温度：　　℃；　湿度：　　%RH、　其它：
Ambient temperature　Humidity　Others

检定结果/说明：
Results of verification and additional explanation

以下空白

本证书提供的结果仅对本次被检的器具有效。
The data are valid only for the instrument(s)

证书编号：468361

检 定 结 果

[illegible]JJG49-1999《[illegible]》国家计量检定[illegible]

[illegible]

[illegible]0.00025MPa

[illegible]0.0005MPa 检定压力[illegible]

标标值（MPa）	压力实际值（MPa）
0.00000	0.00000
0.01000	0.01000
0.02000	0.02000
0.03000	0.03000
0.04000	0.04000
0.05000	0.05000
0.06000	0.06000
0.07000	0.07000
0.08000	0.08000
0.09000	0.09000
-0.10000	-0.10000

以下空白

Table 17. Jenbo Bulbs Specification

JENBO

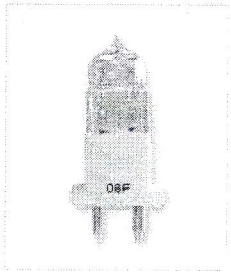
Metal halide lamps

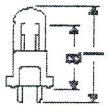
Single-ended

NSK® Product information

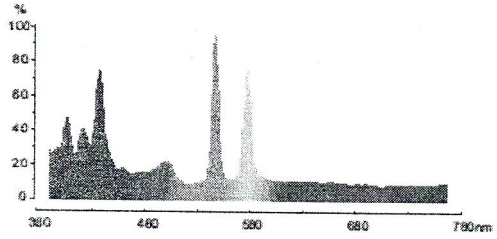
Product reference : **NSK150**

W	Rated wattage	150
V	Rated voltage	90
A	Rated current	1.8
K	Color temperature	6900
lm	Luminous flux	9500
tm	Average life	750
Hr	Hot restart	No
lm/W	Luminous efficacy	63
Ra	Color rendering index	70
	Arc length	5
	Distance a	30
	Max. Length l	46
	Operating position	Any
	Base	GY9.5
	Cooling	Convection
AC/DC	Type of current	AC
	Comparison of type	Osram HTI 150W





Spectral power distribution



www.jenbo.com

JENBO

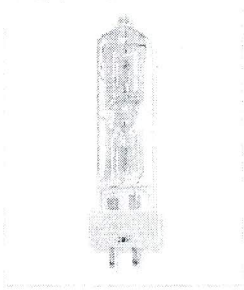
Metal halide lamps

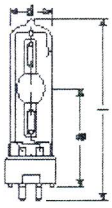
Single-ended

NSK® Product information

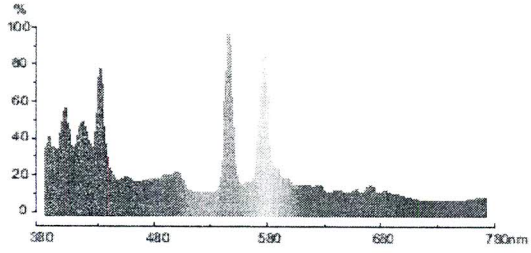
Product reference : **NSK250**

W	Rated wattage	250
V	Rated voltage	94
A	Rated current	3.5
K	Color temperature	6500
lm	Luminous flux	18000
tm	Averaga life	2000
Hr	Hot restart	No
lm/W	Luminous efficacy	72
Ra	Color rendering index	85
	Arc length	5
d (max)	Diameter d	22
a (max)	Distance a	55
l (max)	Max. Length l	108
	Operating position	Any
	Base	GY9.5
	Cooling	Convection
AC/DC	Type of current	AC
	Comparison of type	Osram HSD 250W/60 Philips MSD 250W





Spectral power distribution



1. QUALITY SPECIFICATION FOR JENBO LAMPS

A. GENERAL

A.1 This specification applies to lamp types containing Kr-85

A.2 The JENBO warrants the lamps delivered to be in compliance with the individual QUALITY REQUIREMENTS.

A.3 For approval of lamp quality an inspection may be performed by the recipient in accordance with ISO 2859, inspection level II, if not specified otherwise.

B. DEFINITION OF TERMS

B.1 Inspection lot means a collection of units of lamps from which a sample is to be drawn and inspected to determine conformance with the acceptability criteria.

It usually consists of lamps of a single type, wattage or style, but may be differ from lots designated for other purposes (production, shipments, etc.).

B.2 Test quantity is the number of individual lamps to be tested to determine conformance with the acceptability criteria.

B.3 Test unit is one lamp to be tested.

B.4 Defective unit is a lamp which contains one or more defects:

B.5 Defect is non-conformity of an inspected unit with the product and/or quality specifications.

C. CLASSIFICATION OF DEFECTS

C.1 Defects are grouped into the following classes or sub-classes according to their seriousness:

a. Critical defect is likely to result in hazardous or unsafe conditions for individuals using, maintaining or depending upon the product or to be detrimental to commercial interest.

b. Vital Defect renders a product inoperative or otherwise useless.

c. Major Defect Reduces materially the salability or usability of the product, or a severe appearance defect.

d. Minor Defect is not likely to reduce materially the usability of the unit of product for its intended purpose but is a departure from established standards having little bearing on the effective use or operation of the unit product.

C.2 Quantitative Defects

Is a failure to comply with quantitative product parameters as indicated in the respective lamp specification and tested on units which have passed inspection tests on all qualitative defect classes.

D. ACCEPTANCE/REJECTION CRITERIA

D.1 Lots inspected in accordance with this specification and found to comply with the requirements shall be accepted. In case of non-conformance the recipient is authorized to file a complaint with the supplier.

D.2 To support a complaint the recipient. shall render the technical data of the inspection, as well as the fabrication codes of the unit product and/or box to the supplier. Defective units found shall be kept and made available to the supplier upon request.

D.3 The recipient shall, upon request, authorize the supplier to re-inspect a lot which has been subject to complaint.

D.4 Defectives found in the sample of an accepted lot shall neither be replaced, repaired not credited by the supplier.

D.5 Rejection of a lot can only be based on such defects, which are defined in the respective product quality specifications.

D.6 Changes or amendments to this specification are not valid until mutually agreed upon in writing by
both parties concerned.

1. QUALITY SPECIFICATION FOR JENBO LAMPS

Failure Codes

E-001	lamp non containment during ignition or burning.
E-002	Missing lens
E-003	lamp without front lens or a loose lens ring.
E-004	Broken lens broken lens or a loose lens.
E-005	Bulb contamination
E-006	foreign material inside the lamp which can
E-007	cause non containment.
E-008	Lamp inoperative
E-009	no starting at nominal supply voltage or lamp
E-010	extinguishes within 1 min.
E-011	Damaged pins (Single Ended
E-012	lamp doesn't fit into respective lampholder gauge acc. to IEC publication 61 -3.
E-013	Damaged base threads (Double Ended)
E-014	lamp nut can't manually be screwed on screw thread.
E-015	Leaker cracked bulb, seal, excluding transportation damage.
E-016	transportation damage
E-017	Missing lamp box without lamp.
E-018	Broken foil
E-019	lamp inoperative
E-020	Defective weld
E-021	broken weld between foil and electrode.
E-022	Excentricity of lens
E-023	displacement of the lens regarding the reflector
E-024	Cracked reflector
E-025	Length between base ends (Double Ended)
E-026	lamp does not fit in lampholder.
E-027	base which is found to be loose or becomes loose when inserted into a lampholder
E-028	Cracked leg or outer jacket
E-029	Wrong alignment of tip-off to ceramic lead tip-off points towards ceramic base or is not aligned in ceramic-wire plane
E-030	Broken wire (uncased Double Ended lamp
E-031	Oxidized weld
E-032	The weld outer lead-foil or electrode foil is completely oxidized at both sides of the foil
E-033	The outer lead-foil weld is oxidized(only for free-burning end contacts)
E-034	poor weld between foil and electrode
E-035	Bad etch
E-036	lamp etch misplaced, crooked, partially
E-037	illegible, parts missing or in any way indistinct.
E-038	Excentricity of the burner (Single Ended)
E-039	electrodes not in center of glass bulb.
E-001	Excess twist, lift, alignment of molybdenum
E-002	P 21 Coating peeling off (Brite Beam-)

E-003	P 22 Insufficient solder
E-004	dry solder joint at the end of the pins or the

QUALITY TEST PROCEDURE FOR JENBO LAMPS

Test Procedure

1. Record Bulb type/identification lot number Test/measure light output.
2. Stress the lamp by ten (10) multiple insertions and removals into a typical fixture
3. Establish power at specification voltage and current Wait 24 hours
4. Retest light output
5. Wait 7 days
6. Retest light output
7. calculate relative percent difference (RPD)
8. Acceptance is 95% RPD of initial light output

Test Equipment

Light meter using standard function established by the Commission Internationale de l'Éclairage (CIE) to convert radiant energy into luminous (i.e., visible) energy such as:

Extech 401027-NIST Light Meter, Foot Candle Light Meter with NIST Calibration Certificate

Timer or digital stopwatch

Standard lamp fixture

Calibration test stand

Power Supply

Power Display – displays AC RMS voltage and current

QUALITYTEST PROCEDURE FOR JENBO LAMPS

Test Procedure

1. Record Bulb type/identification lot number Test/measure light output.
2. Measure radiological parameters
3. Stress the lamp by ten (10) multiple insertions and removals into a typical fixture
4. Establish power at specification voltage and current
5. Wait 24 hours
6. Measure radiological parameters
7. calculate relative percent difference (RPD)
8. Acceptance is 95% RPD of initial

Test Equipment

Ludlum 3 (or equal) with pancake probe

Ludlum 3 (or equal) with 43-89 energy compensated GM probe

Measurement Technique

Beta
Record background (cpm) or timed count of 5 minutes
Hold detector window side against lamp in contact with lamp centered over inner gas capsule
Record cpm or counts

Gamma
Record background (cpm) or timed count of 5 minutes
Hold detector (center) with beta window open in contact with lamp centered over inner gas capsule
Record cpm or counts