General Electric
Cathode Ray Tube Dept.

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Report of Visit to R.C.A - Lancaster, Pennsylvania
October 25, 1950

Persons contacted by L.E. Record and V C.Campbell:

Robert Crone	
Austin Hardy	- Screens and color
Mr. McNickel	- Life test
R.D. Faulkner	- Rectangular metal tubes
H. Zacharison	- Inside paints, insulating paints, getters, cathode materials
C. Price-Smith	- Development Shop
Dr. J.C. Turnbull	- Pressure test
W.A. Bentley	- Tube-mounting problems
C.E. Shedd	- Sealing machine
Betty Bell	- Electrostatic Tube Production Engineering
Mr. Britt	- Electrostatic Tube Production Engineering
Dr. L.D. Headrick	- Division Engineer
L. Swedlend	- Design Engineer
H. Selan	- Manager Engineering

We began our visit with Mr. Selan with a general discussion of the Lancaster Development Shop setup. They have approximately 260 people in the Laboratory, of which 110 are in the Development Shop. The total engineering staff is approximately 110 out of which 35 are working directly in the Development Shop. Each Design Engineer keeps from 4 to 6 people busy. We were escorted throughout the day by R. Crone.

21" Metal Rectangular (R.D. Faulkner)

Their present thinking is that this tube should be rated at 16 Kv on the anode. However, they will consider a maximum rating of 16 - 19 Kv if necessary. Their present structural strength on this bulb is between 20 and 40 pounds per sq. in. absolute. They are considering the use of a thinner faceplate of shorter radius on this tube. ITE has been given temporary approval to proceed on the second set of cone-forming tools. They believe that they will request that this set of tools be made for a cylindrical face 21" metal tube.

They are sealing these bulbs on a single-head machine and are annealing at a temperature of 560°C for 20 minutes. This can probably be reduced to 550°C for 15 minutes. They are particulary careful to get the glass above the annealing point before inserting the bulb assembly into the annealing oven.

They believe that if the whole rim is heated as far as 1/2" below the inner edge that good seals can be made. However, they are unable to obtain this in practice. Presently the cone reaches a temperature of 800°C as far as 2" below the lip. This ensures a fairly uniform temperature of approximately 1100°C over the entire sealing surface. They have had considerable trouble with the Pittsburgh 3590 glass and have found that they can make good seals using the higher expansion #3720 glass. In making this seal they are careful to let the glass run down on the flat vertical surface. Then it is blown up slightly such that there is a 3/16" radius on the inside at 1/8" above the metal glass junction. There is no noticable blowup on the top side of the faceplate. The glass surface is parallel to the sealing lip and blends smoothly into the faceplate radius. Failure to form the seal in this manner results in a weak bulb assembly. They have found that if a crevis is left between the glass and the sealing lip that the bulb is 10-20 pounds weaker in pressure test.

We queried them on the problem of eliminating corrosion and blackening the metal cone. They have considered annealing and oxidizing the cone in a bath of molten sodium dichromate. An immersion time of 10 minutes at a temperature of 725 - 750°F will be required. Originally they had thought that this job could be done by a 2 minute immersion and a 10 - 12 minute bake in a radient oven after which the salt would be washed from the cone with tap water.

They are presently using a sodium dichromate coating to blacken the upper 1½" of all their metal cones. This is done to increase contrast and reduce corrosion of the metal cone. This blackening is accomplished by painting the upper portion of the cone with a solution of sodium dichromate dispersed in iso-butylmethylmethacrylate DuPont P5 plastic.

They are also considering the use of a glass neck funnel made by Rodefer Glass Company of a higher expansion glass (94×10^{-7}). The expansion of G12 is 89×10^{-7}.

They plan to use the industry standardized 7-3/16" neck on the 17" and 21" metal rectangular.

<u>17" Metal Rectangular (17GP4).</u>

The 17" tube is withstanding a pressure test of 60 ± 10 pounds per.sq.in. absolute. This is with a faceplate thickness of 7/32" and a cone thickness of 100 mils at the rim. By changing the sidewall radius of curvature they hope to be able to go to 60 or 70 mil material. They feel that if these tubes go through exhaust safely that they are OK to use even though they will ultimately break at a low pressure during pressure test. They have found that the cone tends to heat up faster in the length wise axis and that baffles must be placed in the exhaust oven to heat the cone such that the glass remains in compression at all times. They plan to use radient heaters on the face of the tubes during exhaust to ensure a compression strain at all times. The exhaust schedule will be the same as used on the 16GP4. Their present exhaust rate is 90 tubes per hour, and they are currently life testing tubes made at the rate of 120 per hour. Their present thinking is that they can go up to .2 gas ratio just before getter flash. Previously they had held their sealoff pressure to less than .1 gas ratio. The subject of leadless glass necks came up, and they replied that they had used two carloads of Corning LE glass necks on the 16GP4. This glass contains 2% fluorine, and the sealing temperatures must be watched very carefully as fluorine is liberated. This fluorine combines with the cathode coating, and after exhaust many times there is no emission mix left on the cathode. They found that they have to increase the gun seal-in time and lower sealing in temperature to prevent the fluorine from being liberated.

The subject of low carbon 430 and 1010 cold rolled steel came up. If it was not for the presence of corrosion in the low-chrome steels they believe they could go to a low alloy material. Present thinking is that if we keep the carbon below .03% that 12% chrome steel might be used.

The 17" metal rectangular sealing machine had two semi-circular rim burners with 48 tips each, 24 on either side. These were American Gas 1310A tips. The third burner was made up of an entire ring which lifted from around the tube and consisted of 8 manifolds of 5 tips each. The flames are set such as to be 8 - 10 inches long and just slightly oxidizing. The metal rim reaches approximately 950°C in the first preheat position before indexing 1070°C in the second preheat position and 1170°C in the last position before the tube enters the annealing oven, which is set at 570°C. The heads of this machine rotate at 30 rpm, except for the four positions in the annealing oven. This small machine has 8 heads in all, of which one is used for loading, three for sealing and four for annealing. The index speed is 80 sec.

We inspected their 16GP4 cone sealer which was operating at 40 sec. index speed. This is an 16-head machine and has 6 sealing positions. The first 4 sealing positions are composed of semi-circular burners, 30 tips on a side or a total of 60 tips per position. The last two sealing positions use a complete ring containing 56 burners which lifts out of the way as the machine indexes. There is one ribbon flame on the faceplate, and the first ring of fire is two inches below the lip.

At the same time we also inspected their single head sealing machine which they are presently using to seal the faceplate for the color TV picture tubes. It had a ring burner consisting of 4 banks of dual 5 tip burners, or a total of 40 - 1301A American gas tips.

Pressure Tests (Dr. J.C. Turnbull, R.Faulkner)

They are presently using a pressure differential of forty pounds per.sq.in. as a minimum limit. However, all persons queried on this subject felt that a minimum pressure of 30 - 35 pounds absolute is satisfactory. It seems that glass bulbs are stronger on the one-minute test but are weaker on the one-week test. This is in contrast to the metal bulb which is stronger on the extended test and weaker on the one-minute test. They believe that the one-minute, 50 pound per sq.in. test on the 16GP4 stresses the metal beyond its yielding point. They are currently using a one-week, 30 - 35 pound per sq.in. on the 16GP4. They get 2% failures at 50 per sq.in. on the 16GP4 and 2% failures on the 12LP4 at 65 - 70 per sq.in. This is in contrast to the 35 - 40 per sq.in. which the 21" metal is currently withstanding.

They believe a 45 lb. for one minute is equivalent to 20 pounds per sq.in. for ten years. They had the following experience on the 17" metal tube which was tested at 20 pounds initial pressure increased at the rate of 5 pounds per each one minute interval until failure.

Average breaking stress	62 ± 5 psi. abolute
1% failure	50 psi
5% failure after 1 week	30 psi absolute

They have found that the metal body fails at 40 pounds per sq.in. under extended pressure tests. There is a 3 to 1 increase in breaking if the seal area is abraded in any way.

They have made some tests on faceplates and find that their strength alone is between 8 - 10 pounds absolute. These were placed on rubber rings and evacuated.

<u>Screening (A. Hardy)</u>

They are doing considerable screening on tables and are using pouring racks which can be reset very fast. Their standard procedure is to introduce the phosphor following two steps which consist of 1/3 cushion water, 1/3 sulphate and silicate mix repeated twice, followed with a mixture of the phosphor and 1/3 cushion water and 1/3 sulphate and silicate. They are currently milling their phosphor in one gallon abb• ball mills. These mills contain 2000 grams of slugs and are rotated at 60 rpm for 40 minutes. A mixture of 800 cc of one normal potassium sulphate and 500 grams of 6 - 7 microns particle size phosphor is used.

After milling the phosphor is removed from the jar, the jar rinsed and the phosphor suspension diluted to a 12.8 milligram per cc concentration.

A typical process as applied to the 16GP4 is as follows:

> They wash the inside and outside of the tube neck with ammonium bifluoride and rinse with water before screening. They introduce 1300 cc of water plus 150 cc of silicate plus 250 cc of sulphate followed by 400 cc of distilled water rinse as the first step. This is repeated again, and the third step consists of a mixture of 1300 cc of water, 300 cc of phosphor suspension (3.5 grams), 150 cc silicate, 250 cc sulphate followed by a rinse of 400 cc water. The water temperature is between 52 and 53°F and the room temperature is at 73-74°F. The screens are allowed to settle from 45 - 60 minutes and are then poured off in about five minutes' time. They find that to prevent water marks on the metal tubes with poor seals, they must vacuum dry for a period of ten minutes or more at a vacuum of 30 inches of mercury. Their vacuum driers have a small calrod heating unit unit surrounding the neck metal glass seal. This hastens the drying of the cone and prevents water from remaining on the inside where it may run onto the phosphor screen.

As we were particularly interested in their use of barium nitrate as an electrolyte, we looked into this process very carefully and were amazed to find that they are using only 62 cc of potassium silicate (10% by weight) - Kasil is 28 - 29% SiO_2.

They are using a single cycle method with the barium nitrate for introducing the solutions into the bulb. The overall volume is 6500 cc. They introduce approximately 1/3 of the solution and all of the silicate in the first step. This is then followed with the balance of the cushion water which contains 385 cc of phosphor, suspension of 12.8 milligrams per cc concentration and .5 grams of barium nitrate. The water temperature at the start is 55°F. Setting time is 40 - 45 minutes on the belt. They have found this process to be very critical in that if the amount of water used is too much or too little that the screens slip off very badly. They find that a slightly heavier phosphor weight of 4.5 grams per sq. centimeter is desirable. This gives a 600 - 700°K bluer color, and they use a slightly different phosphor blend to give the same color as the tubes settled on the screening table. The use of this process with the very small amount of potassium silicate as compared to what we use enables them to dispense with vacuum drying without fear of water mark shrinkage. When queried as to the extent of raster burns with this process, Mr. Hardy felt there was very little difference. They were running some 14EP4's -- which is a 14CP4 without outside coating -- on the conveyor belt. The following solutions were introduced.

3500 Ml cushion

320 Ml 10% silicate + mixture of 200 Ml Z623 phosphor suspension 12.8 mg. per cc

350 cc of 1 normal potassium sulphate

This is followed by 350 Ml water rinse and a settling time of 45 minutes. A cushion water temperature of 67°F seems to give uniform screens.

While in the screen room with Mr. Crome we talked with Mr. Solt and F. Leanza and obtained the attached table of screen application specifications.

Screen Conveyor

They are using the same screen conveyors which have been described in numerous other trip reports. We watched these conveyors carefully and observed absolutely no wiggle or shake or vibration of any sort. At the pouroff end on either side of the wheel they have a large circular casting containing a thick rubber gasket. This presses down on a 1½" ballbearing attached to either side of the bulb holder tray. This prevents the tray from pulling away from the conveyor sprocket wheels as seems to be the case with our machines. They also have wippers following all the wheels on these trays so as to remove bits of dirt, broken glass, etc. Baring surfaces are oiled by wicks dipping into containers of oil. There is no heat on this conveyor.

Screen Bakeout and Inside Bulb Paint

We watched them brush the 16GP4's and 14EP4's with their ammonium-free inside graphite paint 33-Z-610. Three brushes are required to brush the graphite on the 16GP4. The first brush used is rather long and has a brush length of approximately 4". With this brush they coat the inside of the metal cone to within about 1 - 1½" of the screen and down to about 1" of the lower sealing lip. The second brush is a short stubby brush approximately 1/2 x 1/4" and is used to insure a good coating between the metal cone and the glass funnel. The third brush is similar to those which we use and is used to paint the glass funnel and neck.

Following the painting, the bulb assembly is placed on a hot-air drying rack and is dried for approximately 3 or 4 minutes, after which its neck is covered with a ventilated cap and the bulb placed in a surface combustion lehr similar to our annealing lehr, for screen and coating bakeout. This lehr is operating at a temperature between 405 and 420°C. The 14EP4's are coated with graphite to within 1" of the face. This is the time-consuming operation and the operator does an extremely neat job. The upper edge of the coating is very smooth and even. After the graphite has dried, the 14EP4's are placed face down on special holders and run through the screening lehr for bakeout.

Bulb Wash

They are using the same two 12-head bulb washers described in a previous report. These machines are similar to our Peter Dalton machines in Buffalo. They are operating on a 15 sec. index of which about 5 sec. is used in the indexing operation. The machine is using a 3% bifluoride solution. This is made up from crystalline ammonium bifluoride purchased from the Harshaw Chemical Company and is specified as #104. Rework 16GP4's are cleaned with a 7 - 8% ammonium bifluoride solution on a hand-operated unit. They sometimes find it necessary to brush the inside of the metal cone to remove all of the graphite.

X-Burn (A. Hardy, H. Zacharison, L. Swedlend)

We discussed this problem at great length. They are using a method of detection similar to the one which we use and find that a 1" circle of graphite and a 3" sq. raster on the center of the metal tube faceplate gives them good results. They have been able to reduce the screen potential to within 60 volts of the anode voltage at 20 Kv for either suphate or barium nitrate type screens.

They have found that the screen weight must be no lower than 3.8 milligrams per sq. centimeters if X-burn is to be avoided. This weight applies for a phosphor in the 6 to 7 micron particle size range. They are presently using a 4.5 milligram per sq. centimeter screen weight. Originally they had used a 4 milligram weight. They believe that our freedom from screen sticking potential and consequently X-burn is the result of our heavier screen weights coupled with our method of screening. It seems that our method of screening leaves a higher percentage of silica in the phosphor; they have found that there is a minimum amount of silica which must be present if good secondary emission is to be obtained.

Life Test (Mr. McNickel)

Life test conditions and results were discussed with Mr. McNickel, and the following information obtained.

16GP4

Anode Voltage	15.5 Kv
#2 grid voltage	450 volts
Beam current	200 microamps
Screen size	
Horizontal	Slightly over scanned
Vertical	3/4 horizontal width

16GP4 (Cont'd)

Focused raster

Heater cathode bias: 500 volts for the first 15 seconds of each cycle, at which time the voltage is dropped to 210 volts for the remainder of the on and off cycle.

These tubes are cycled by turning off only the heaters and allowing specified voltages to remain on the tube elements. The cycle time is 13 minutes on and 7 minutes off.

Life test readings are taken at the following intervals:-

0, 100, 300 and 500 hours.

One tube a month is run on life test until failure or 5,000 hours, whichever occurs first. Mr. McNickel reports they are currently averaging about 2500 hours life. He stated that this has not always been so and that up until vacation the average life under the above conditions was between 250 and 500 hours.

He was unable to tell me the reason for their recently improved life. I persued this subject further with the other men contacted, none of whom were able to shed any light on the matter.

Mr. Zacharison thought that the short life may have been due to too thin a cathode coating. Mr. R. Crone thought it might be attributed to too low a screen bakeout temperature.

They are currently estimating a life expectancy of 3000 hours for the 10", 2500 hours for the 12" and 2000 for the 16" such as the 16A and 16GP4. They are presently testing on life test 19AP4A made in Marion, Indiana, at 15 Kv and a beam current of 200 microamperes. They refused to comment on the life of these tubes saying out of one side of their mouth that they pass life test and out of the other side that they have not completed any tests. They did say that the DuMont bent gun design was giving them some ion spot trouble, and they were seriously thinking of following our lead, i.e. they will use the tilted ion trap gun in their 19" metal tube.

Their general life test criteria is to test at max. max. anode voltage and to use a constant screen current density of approximately one microampere per sq.in. They are using a raster with a May West shape 3 units high and 4 units wide. They have limited cathode current on life test to an upper limit of 200 microamperes, as they do not believe that any of the receivers now used will supply more current than that.

Conductive Insulating Paints, Getters and Cathode Mixes (H.Zacharison, L. Swedlend)

They are presently using two insulating outside paints 33-L-608 which is a vinyl plus chlorinated rubber based paint and 33-L-632 which is an asphalt based paint. The asphalt based paint is a combination insulating and decorating paint somewhat cheaper than the vinyl paint. It has one disadvantage in that it requires more drying time than the #608 paint and must be removed with kerosene. The vinyl based paint dries faster and can be stripped from the metal cone with Oakite M3 metal stripper. They test these paints on 5TP4 projection tube bulbs, which have a conductive painted band surrounding the bulb and passing over the outside of the anode button. The neck of this tube is likewise coated with insulating paint up to the reference line. This leaves a leakage path of 2 - 2½" long. These bulbs are sprayed with the insulating paint to be tested and six samples are placed in a humidity box which is operated at 92 - 93% relative humidity at 95°F. Their present acceptable limit is less than 50 microamperes leakage at 16000 applied volts. A good paint will average about 10 microamperes leakage. They are definitely in trouble if the glass is not cleaned before the paint is applied; and in particular if there are any silica streaks they find no paint will pass this test. Originally they tested only for corona which they detected by use of a small dipole antenna probe and placed near the bulb connected to a receiver. They then looked for noise in the picture resulting from corona breakdown. Their experience with the theatre projection tube and the 5TP4 projection tube and the various metal tubes have given them this figure with respect to voltage gradient per inch. A conservative rating is 4000 volts per in., 8000 volts per in. is considered OK with a good insulating paint, and if care is used they find that 10000 volts per inch is perfectly satisfactory. Incidentally, the 5TP4 projection tube, when operating at its rating of 27000 volts, is subject to a gradient across the bulb of 10000 volts per inch.

Several other engineers were contacted on this matter of insulating paint and all were very emphatic in their insistance that there must be no potassium silicate on the glass funnel. They state that it cannot be satisfactorily removed with hydrofluoric acid washes, and it is their practice to remove this silicate by a buffing and polishing operation. Furthermore all of the tubes are warmed and dried before any insulating paint is applied. It is their practice to use one paint for insulation and decorative purposes. No conductive rim paint is used.

(Getters)

We discussed the subject of getters and gettering methods. Mr. Zacharison favored the batalum type getter for the following reasons. It is easy to out gas without flashing prematurely, and it gives a good yield of barium. He has tested it in comparison with the Kemet type getters and finds it to be only only slightly better. However, they have had trouble degassing and flashing the Kemet getter. The Kemet getter is apt to burn out, whereas the batalum getter with its molybdenum channel does not. They have also tried some King Barex type pellet getters. They have some tubes on life test with these getters.and were unable to say whether they would be satisfactory. They presently use two types of batalum getters -- Barium Beryliate, B-76, which is reduced by titanium when the mixture is heated. This is probably slightly better than the other material B-81 which is a barium titinate material that is reduced by beryllium powder. Because of U.S. Bureau of Mines regulations they are being extremly careful about the beryllium compounds. These getters are mounted under little exhaust hoods, and the operators are periodically checked for evidence of beryllium in their blood streams. As yet they have detected no signs of beryllium absorption by the operators. There is no hazard to the manufacturer of these getters except after the material is dry and apt to be broken out of the channel.

They are flashing their getters without the use of windows, as this practice saves them some money in the brushing operation. They do not believe they could do this with any other gettersthan the batalum design.

(Cathode Mixes)

They are using the same mix which they have been for a long time. They take special care in the cathode spraying operation to ensure a coating which is dense but not so hard as to chip off when scratched with a sharp instrument. The coating is currently 1.5 to 2.5 mils thick. They are using a one-piece cathode sleeve and cap. The cathode ceramic is prevented from sliding over the head by a bulged and sweged ring about 1/10" from the cap. The ceramic insulator is then held on with an eyelet.

Aluminizing and Spray Filming

They film their 5TP4 by the spray filming method and are planning to use this method if necessary on the 19AP4 in their Marion plant. The unit uses a spray nozzle made by Spraying Systems, Inc. The trade name for this nozzle is Sprayco. This nozzle is used to spray a mist of water over the phosphor before the plastic solution is sprayed. They are using a DeVilbis spray nozzle for the plastic material. The metal bulb is spun at approximately 60 rpm during the spraying operation which coats a patch of screen about 8" in diameter. As this plastic material is rather thin, it flows outwards by centrifugal force and covers the entire screen. If the cone walls are maintained in a wet condition, the surplus plastic material may be easily stripped from the walls of the tube. They are using the following material for the spray film - poly-iso-butylmethylmethacrylate. This is DuPont's P5 plastic material. A typical mixture is-

60 grams P5   250 ml toluene   ½ gm. B72 plasticizer (Rohm Hass acrolyoid B72 resin)

They aluminize at a vacuum which is no worse than .3 microns and use an aluminum thickness of approximately 100 millimicrons. This is the thickness which we attempt to get on the 10FP4 for the purpose of surpressing the ion burn. They have found that if they are to obtain this good vacuum they must use filament rods at least ¼" in diameter to keep down heating of the bulb neck during aluminizing.

Miscellaneous Notes

Their 18 milligram batalum getter yields 18% or 3¼ milligrams of free barium. They age the same as we do except for a negative voltage on the anode.

They obtain purple spots when they mix the phosphor in the kasil potassium silicate and put the barium nitrate in the cushion water. If they mix the phosphor with the barium nitrate and place the silicate in the cushion water, purple spots disappear. They are making P7 screens these days using a very fine blue component with their coarser yellow. This material is introduced mixed together and blue settles down on top of the yellow material. They expect to go to this method 100%.

They are investigating the welding of two metal standoff supports on the rectangular metal cone. These will be made from 18-8 stainless steel and be threaded for ¼ - 20 thread. The Ohio Nut and Bolt Company are making their welds.

They check the efficiency of the blackened inside metal cone by using a light tight box separated down the middle which contains a light source on one side and a photo cell on the other. The light cell must read no more than 1/9 as much on a blackened cone as it does on an unblackened one.

L. Swedlend maintains that the 6-7/8" neck gives a 10% smaller spot size than the 7½ size which we use on the 16KP4. They will go along with the 7-3/16" neck but feel that it is not quite as good as the short neck.

Austin Hardy reports that they measure screen color on all tubes with their spectroradiometer and use a weighted ordinate method of determining the ICI points. They were quite interested in our 4-filter direct reading colorimeter for use in factory and quality testing. They did not feel that it had to be as accurate as a radiometer as long as it was sufficiently accurate to keep them within the specified limits.

We talked a little about substitute materials. They are going to 18-8 in place of 18-12 stainless steel, and on many parts are considering the use of nickel plated steel. They know of no substitute for the nickel manganese alloy used in the upper part of the stem lead.

They believe iron or nickel plated iron would be too soft as they mount the gun on but two stem leads.

They are inspecting screens in a light inspection box containing 12 - 40-watt fluorescent lamps and above this unit have a number of illuminated faceplates with blemishes indicated thereon. This helps the operator to do a good job of screen inspection.

They are using a white plastic paint made by Farbol to mark on faceplates as this material burns off and leaves no mar on the faceplate.

They wash the inside and outside of each tube neck before screening and after screening to remove dirt which might fall on the screen and silicate which might interfere with sealing.

They are making an improved flying spot scanner tube C73172. This is similar to the 5TP4 projection tube but has a longer gun and a reduced deflection angle. The phosphor used is a calcium magnesium silicate which is activated with cerium. This material is similar to zinc oxide in spectral emission characteristics except that it has a longer decay time which they find can be compensated for very easily. The important features of this phosphor is that it is unaffected by current density.

V.C. Campbell

VCC/jd 12-8-50

V.C. Campbell
Cathode-Ray Tube Engineering

Tube Type	Fluorescent Material Wt.	Screen Wt. Mg/Cm^2	Cushion Water Volume	Volume of Phospher Suspension at 12.8 mg/cm^2 Z623	Kasil Brand Potassium Silicate (10%)	Potassium Sulfate Vol. 1 Normal	Rinse Water Volume	Settling Time in Minutes
7DP4	806	3.6	400	63	60	100	170	60
7JP4	687	2.65	1200	53	120	200	200	60
10BP4	1602	3.5	1200	125	150	250	200	30
1816	1602	3.5	1200	125 of Z636	150	250	200	30
12LP4	2520	3.5	2500	197	320	350	350	30
14EP4	2275	3.5	3500	180	320	350	350	45
16AP4 Solutions added in three steps	3842	3.5	1600 1600 1600	- - 300	150 150 150	250 250 250	300 300 300	45
16GP4 Solutions added in three steps	3842	3.5	1300 1300 1300	- - 300	150 150 150	250 250 250	400 400 400	45