

Ram-Ray Valley Energy failure on Detector Final Test

- During the 1st & 2nd week of Jun, Production encountered high failure on Ram-Ray Valley Energy during detector final test for 5029 model. Ram-Ray Valley Energy values are lower than the specification.
- Spec of Ram-Ray Valley Energy 5000 to 100000
- The UUTs were passed the test after replacing fresh new PMTs.
- 11 pcs of PMTs were replaced.
- Specification of Hamamatsu PMTs are defined by dark current, anode sensitivity, cathode sensitivity, etc.. And unable to translate to ours due to different application and test method. Also it is not possible to measure above parameters based on our capability.



13788 Hamamatsu
PMT

- The failed PMTs performed the following investigation:

Possible Root cause:

- 1) PMT itself having a lower reading?
- 2) 5029 models are getting lower spec/ref energy of gratings (bad gratings). It might cause the failure?



Evaluation 1

1) Failed PMTs used in 2475 Models

S/No	Test Date	Ram-Ray Valley Energy	PMT S/N	FRU units S/No	Ram-Ray Valley Energy
E18UPF711G	1-Jun-18	3510	NAH9463	1805110-03	12348
E18UPF724G	11-Jun-18	2882	TAC4796	1805110-04	15097
E18UPF716G	4-Jun-18	4403	TAC4464	1805110-02	11882
E18UPF712G	1-Jun-18	3336	NZP4571	1805110-01	9364
E18UPF722G	9-Jun-18	3767	NAH9504	1805110-05	7955
E18UPF722G	26-Jun-18	4724	TAC4796	F18UPF752G	13697

***Remarks:**

Found that the passing data at 2475 are also lower than 2475 normal passing data range of 2475 models.



Evaluation 2

2) To try with good efficiency gratings in the 5029 models

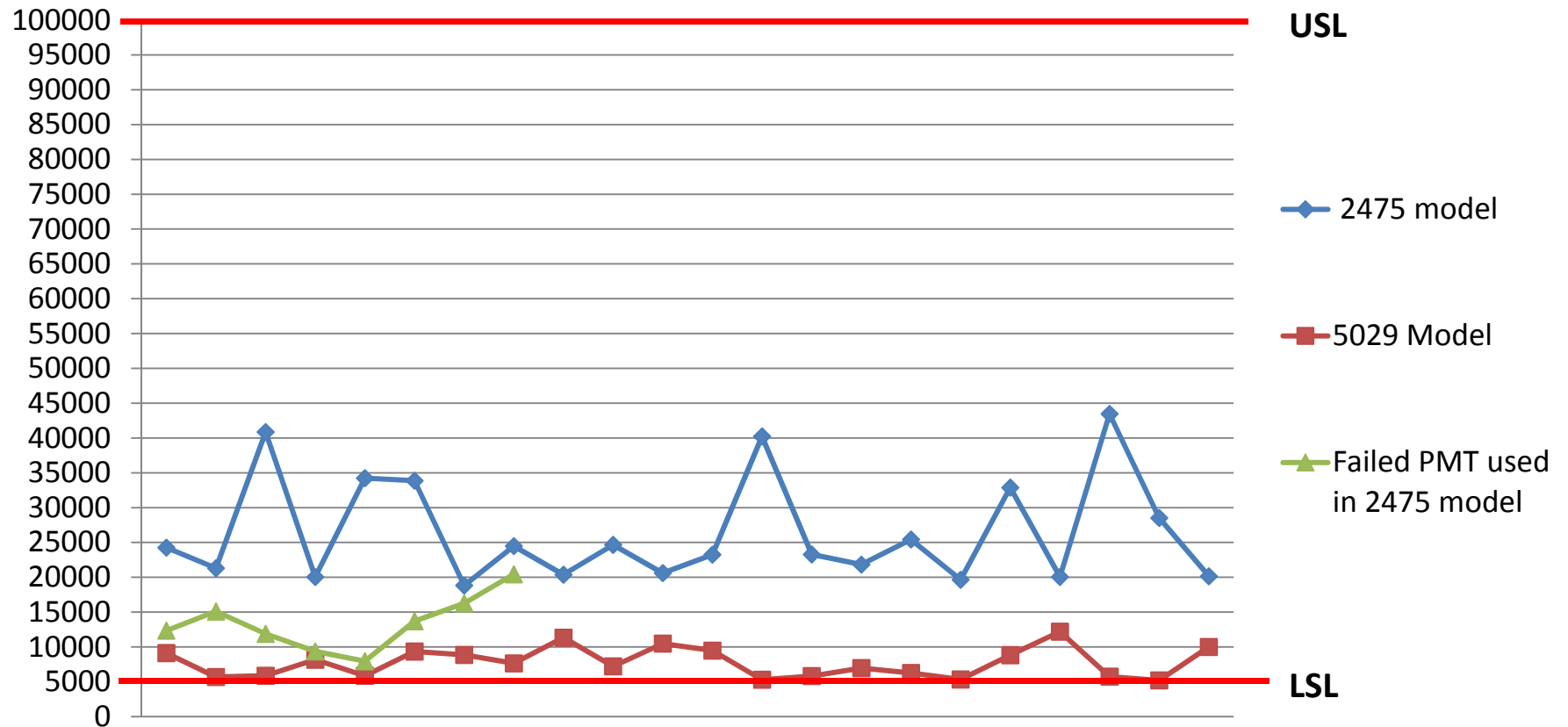
S/No	Test Date	Ram-Ray Valley Energy	PMT S/N	5029 UUT S/No	Ram-Ray Valley Energy	Optics Bench S/No	Ram-Ray Valley Energy	2475 UUT S/No	With original PMT
E18UPF724G	12-Jun-18	4561	TAC4790	F18UPF734G	9154	1806007-11			
E18UPF727G	9-Jun-18	3921	NAH9465	F18UPF740G	4643	1806054-02	15359	F18475267G	56625
E18UPF725G	9-Jun-18	4359	TAC5443	F18UPF742G	9422	1806054-01			
E18UPF719G	8-Jun-18	4830	TAC5135	F18UPF735G	7426	1806007-12			
E18UPF715G	4-Jun-18	4724	TAC5456	F18UPF741G	3613	1806054-03	20434	F18475261G	47020

Summary:

From above 2 evaluation we suspected the failed PMTs itself having a lower reading than other PMTs.



Ram-Ray Valley Energy of 2475 vs 5029





Normal production 2475 & 5029 Ram-Ray Valley Energy data range

2475 model	Ram-Ray Valley Energy
B18475039G	24260
B18475044G	21309
B18475067G	40859
B18475061G	20046
B18475053G	34234
C18475125G	33868
C18475126G	18829
C18475129G	24480
C18475134G	20376
C18475135G	24660
D18475137G	20610
D18475138G	23252
D18475139G	40231
D18475140G	23285
D18475172G	21824
D18475193G	25431
D18475188G	19653
E18475198G	32881
E18475199G	20061
E18475200G	43464
E18475202G	28520
E18475221G	20151

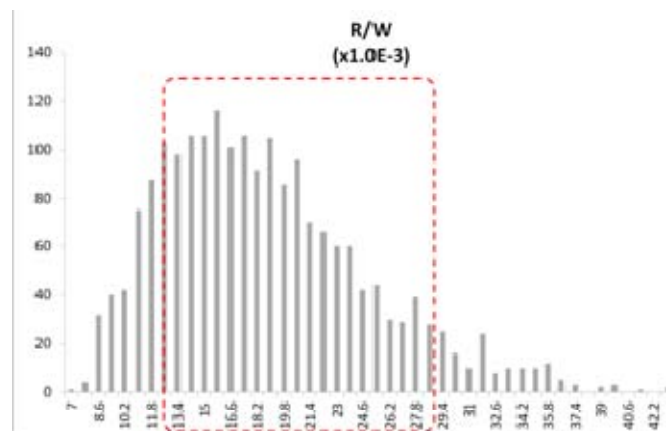
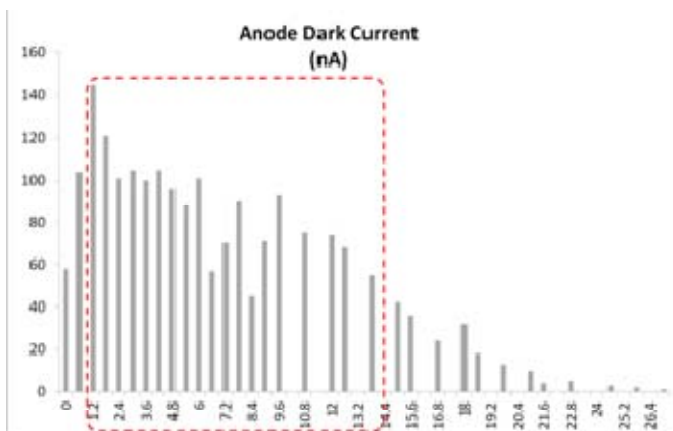
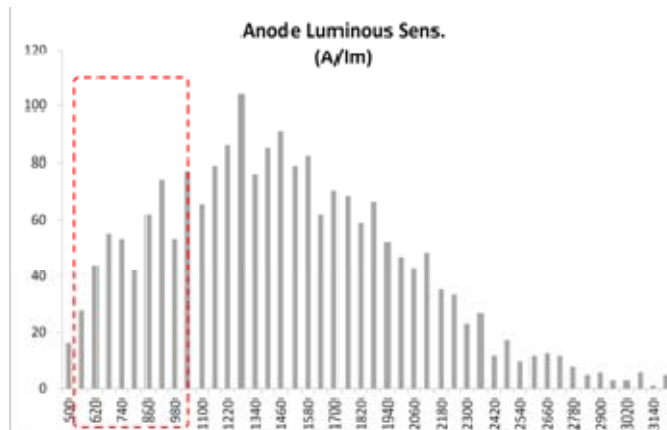
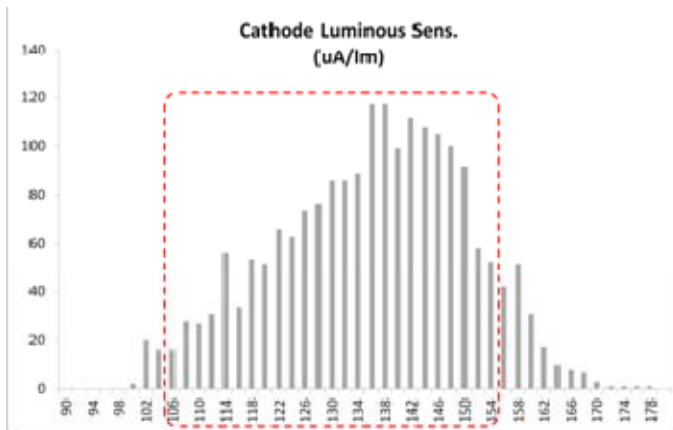
5029 Model	Ram-Ray Valley Energy
B18UPF542G	9124
B18UPF545G	5692
B18UPF565G	5869
B18UPF559G	8174
B18UPF572G	5861
C17UPF041G	9347
C17UPF618G	8860
C17UPF644G	7645
C17UPF614G	11341
C17UPF597G	7211
D18UPF649G	10483
D18UPF657G	9483
D18UPF667G	5302
D18UPF668G	5825
D18UPF674G	6967
D18UPF698G	6263
D18UPF673G	5333
E18UPF711G	8822
E18UPF714G	12193
E18UPF682G	5745
E18UPF704G	5199
E18UPF707G	10008

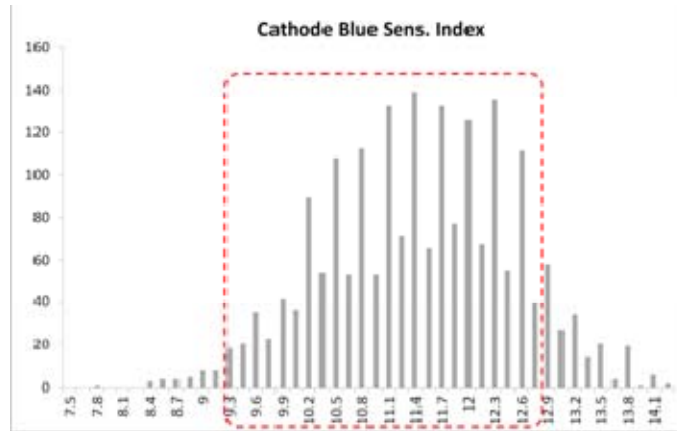


- Preliminary analysis on the data supplier provided.
- According to supplier's record, the test data for 14 sets PMTs that we requested were picked out as list below. The ship date for these 12 sets PMTs are at **March or April of 2018**, 2 sets were at **December of 2017**.

Item#	Serial#	HPK Ship Date	Customer	Cathode Luminous Sens.	Anode Luminous Sens.	Anode Dark Current	R/W	Cathode Blue Sens.
R3788HA	TAC4464	8/3/2018	6052	124	527	2.2	15.6	10.6
R3788HA	NAIB504	7/12/2017	6052	128	533	2.6	26.9	10.6
R3788HA	TAC5047	8/3/2018	6052	148	534	8.9	28.7	11.6
R3788HA	NAIB465	8/3/2018	6052	130	538	4.7	18.2	10.8
R3788HA	NAJ0060	25/4/2018	6052	115	540	6.6	16.7	10
R3788HA	NAIB463	7/12/2017	6052	139	545	3.2	12.8	11.5
R3788HA	NZP4571	25/4/2018	6052	150	581	14	12.3	12.1
R3788HA	TAC5135	8/3/2018	6052	123	594	1.1	15.5	10.2
R3788HA	TAC5456	25/4/2018	6052	115	630	2.8	25.4	9.51
R3788HA	TAC5199	28/3/2018	6052	150	631	2.7	16.7	12.4
R3788HA	TAC4796	28/3/2018	6052	135	664	2.7	19	11.1
R3788HA	TAC4790	28/3/2018	6052	105	761	5	16.8	9.26
R3788HA	TAC5012	28/3/2018	6052	115	918	6.8	18.3	10.4
R3788HA	TAC5443	25/4/2018	6052	155	1050	13	14.3	12.8

- Known from supplier's record that **5 test** items were conducted on every PMT under supplier's test condition. Our actual application is different from supplier's test condition, but we still could try to understand the relevance between them.
- Based on this test record, distribution chart for every item as following.

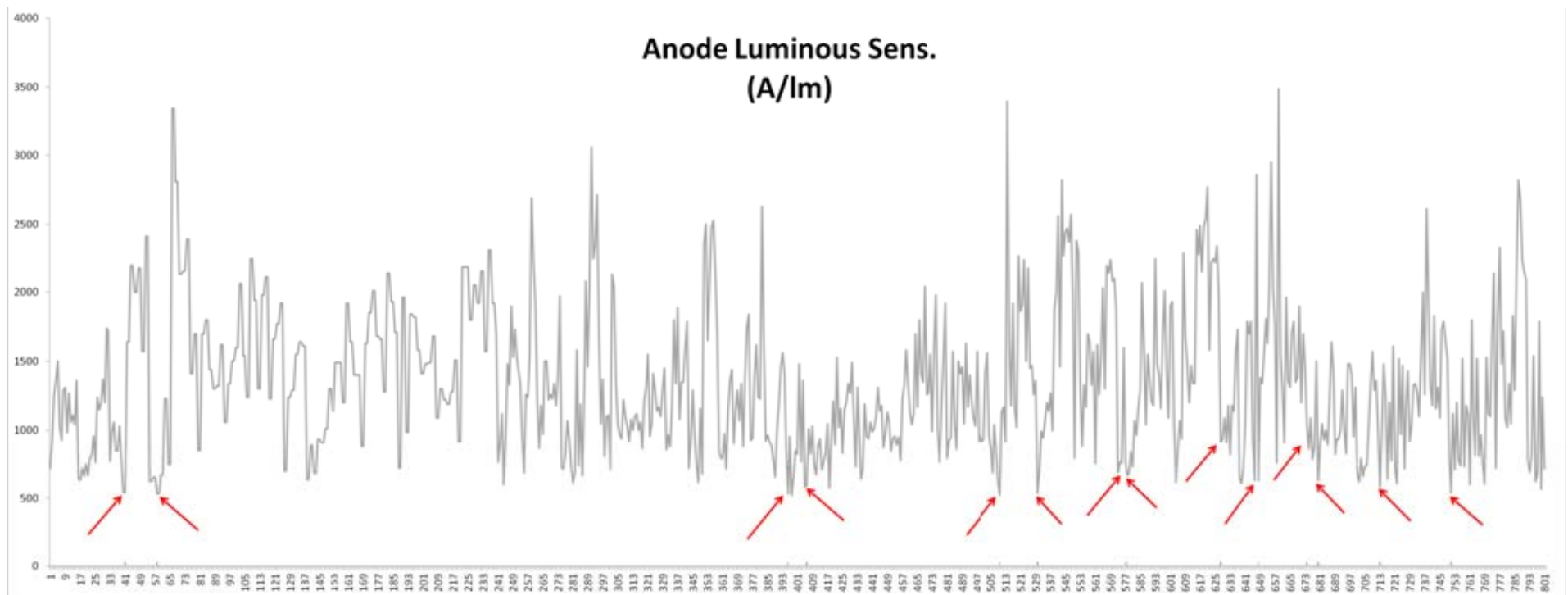




- On above every distribution chart, the X-axis stands for the range of test result and the Y-axis stands for the number of times of the test result dropping in corresponding range.
- The **dashed red box** highlights the rough range of test result for 14 sets above-mentioned PMTs.
- Obviously, except for “Anode Luminous Sens.” (the 2nd one), the test results for other 4 test items are in a large scale range.
- In other words, the test result is random without similarity. However, the result for “Anode Luminous Sens.” is different. In this second chart, the test result for 14 sets PMTs are obviously gathered at lower-end of record range.



- To verify this finding, an overview of record for “**Anode Luminous Sens.**” was charted and the test results for 14 sets PMTs were pointed by red arrows.
- The 14 sets PMTs’ test result are all almost at the lowest end. So, it’s suspected that the failure on PMTs is related to its low Anode Luminous Sens.





- Above charts just show the relevance between failure and low “Anode Luminous Sens.” rather than the cause-and-effect relationship. This relevance is only based on observation on 14 sets PMTs.
- Next step of evaluation will be choosing **3 sets PMTs with low “Anode Luminous Sens” reading , 3 sets PMTs with high reading to test R-R Valley energy and 3 sets of PMTs with nominal readings and test with single UUT.** If their test results also prove preceding relevance, we may get a strong clue to find out the root cause.
- If above relevance was proved, according to the overview of supplier’s test record, we may encounter this R-R Valley Energy issue more and more.