



ANGRA 1 STEAM GENERATOR REPLACEMENT



MARCOS ANTONIO DO AMARAL
RADIOLOGICAL PROTECTION DIVISION MANAGER



ELETRONUCLEAR
ELETROBRÁS TERMONUCLEAR S.A.

13/10/2009

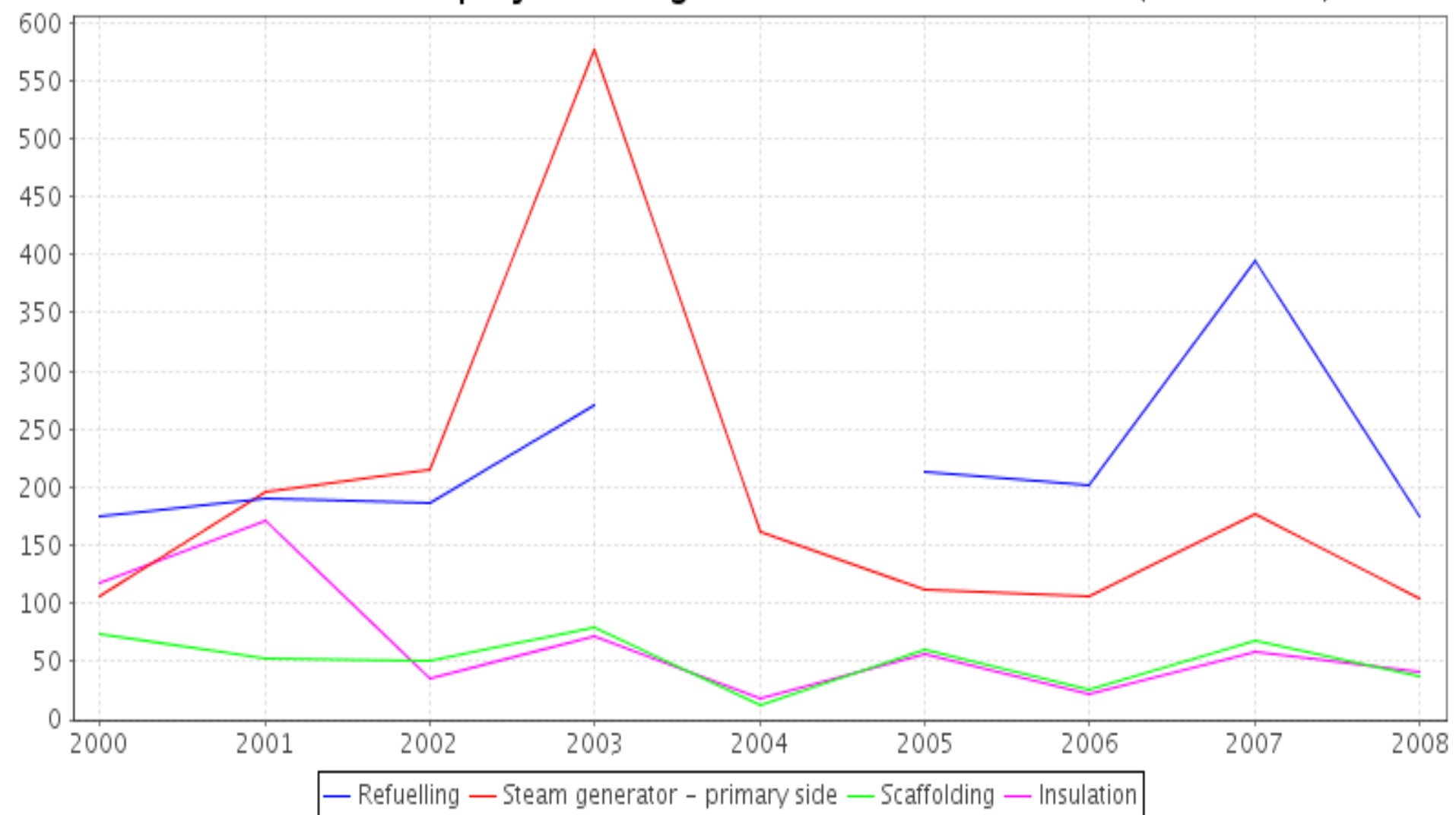
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CHRONOLOGY

- 2003 – 1P12 – High Primary to Secondary Leak Rate – 2041 man.mSv
- 2004 – 1P12A – 100% ECT – 607 man.mSv – No Refueling
- 2005 – 1P13 – 1,157 man.mSv
- 2006 – 1P13A + 1P14 – 938 man.mSv
- 2007 – 1P14A + 1P15 – 1,827 man.mSv – FM in RCS + RCP burned + spent resin in RCS + waste evap.
- 2008 – 1P15A – N-1 Outage – 1,109 man.mSv

CHRONOLOGY

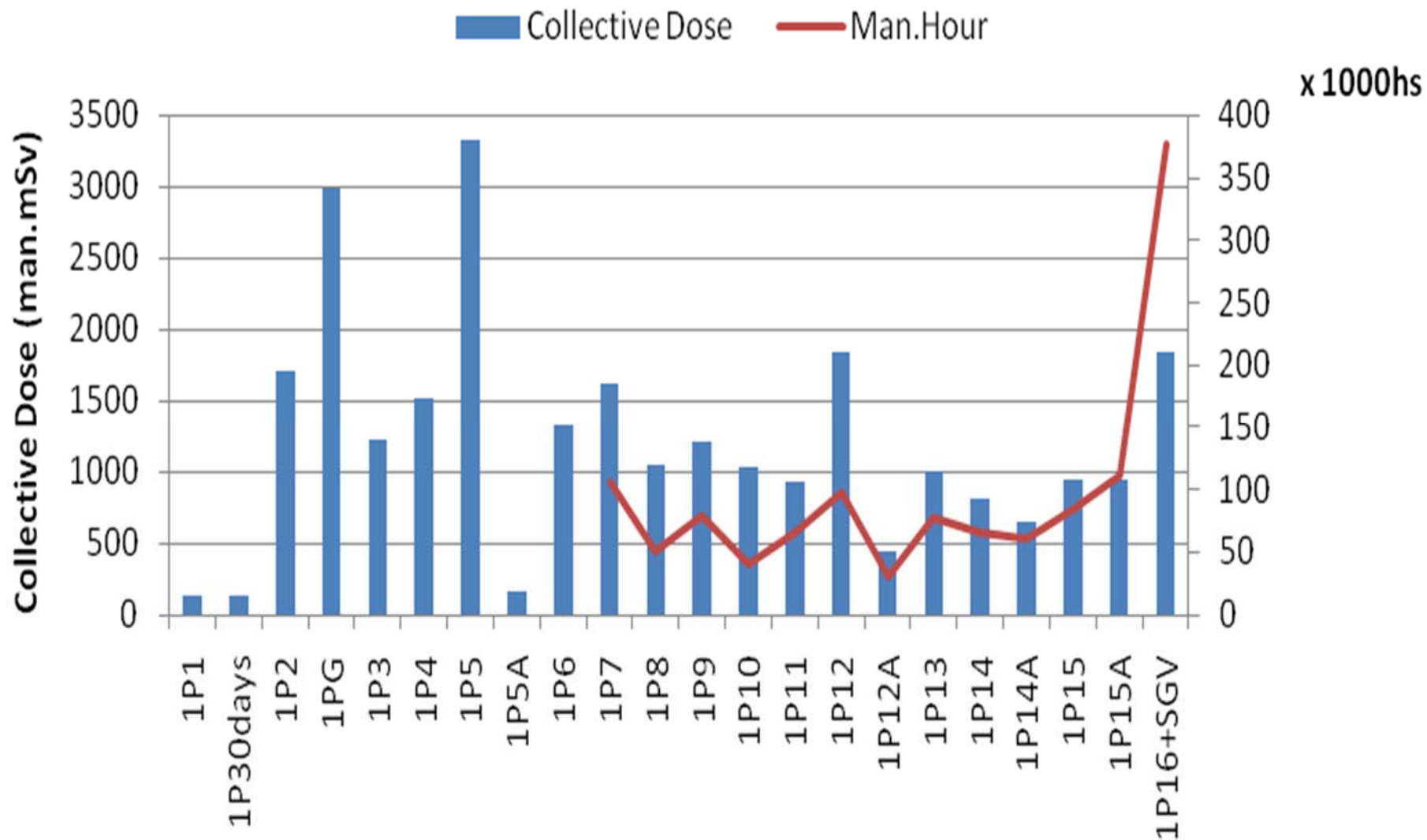
Evolution of the dose per job for Angra 1 between 2000 and 2008 (in man.mSv)



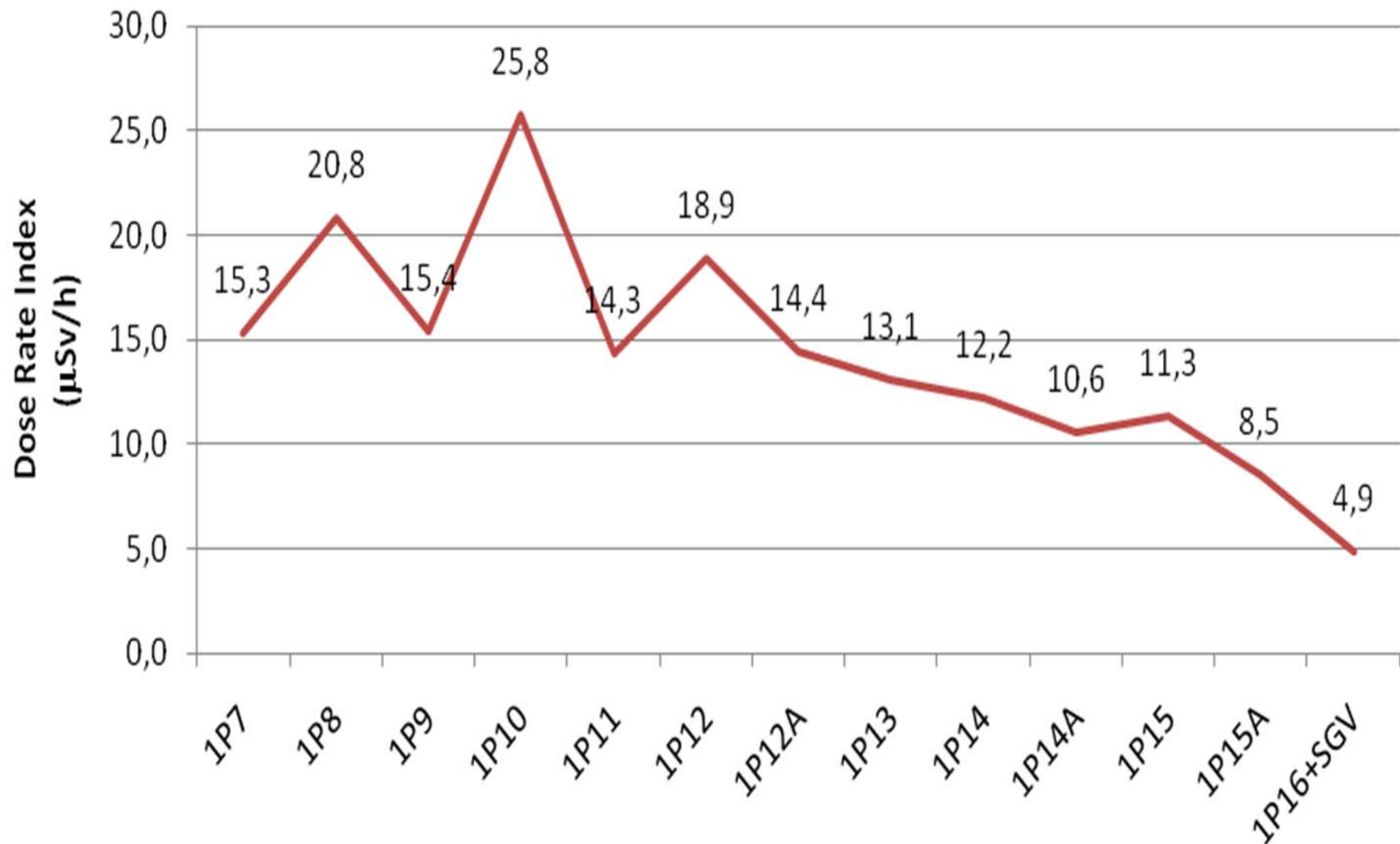
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Source: ISOE

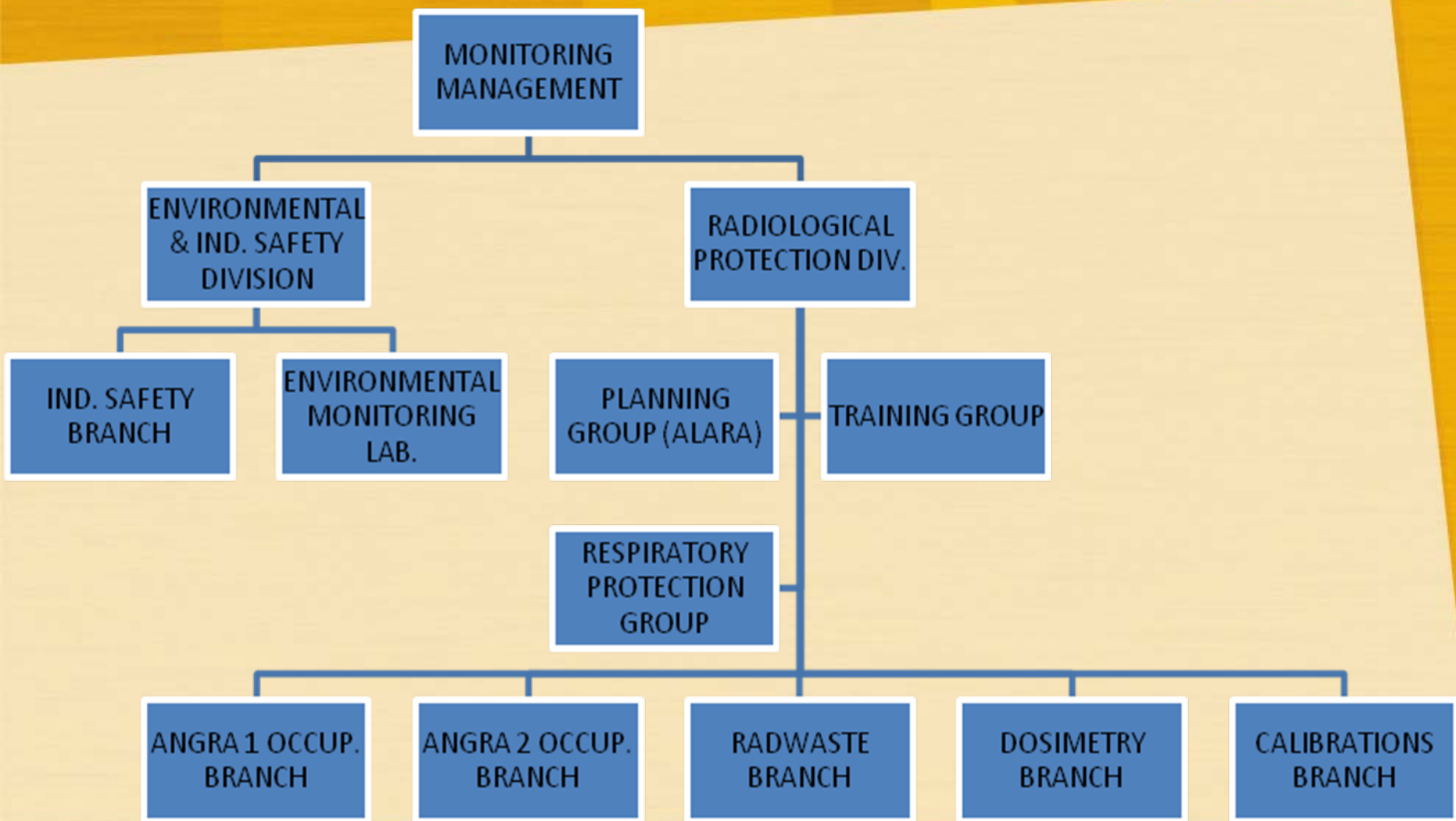
CHRONOLOGY



CHRONOLOGY



RP ORGANIZATION

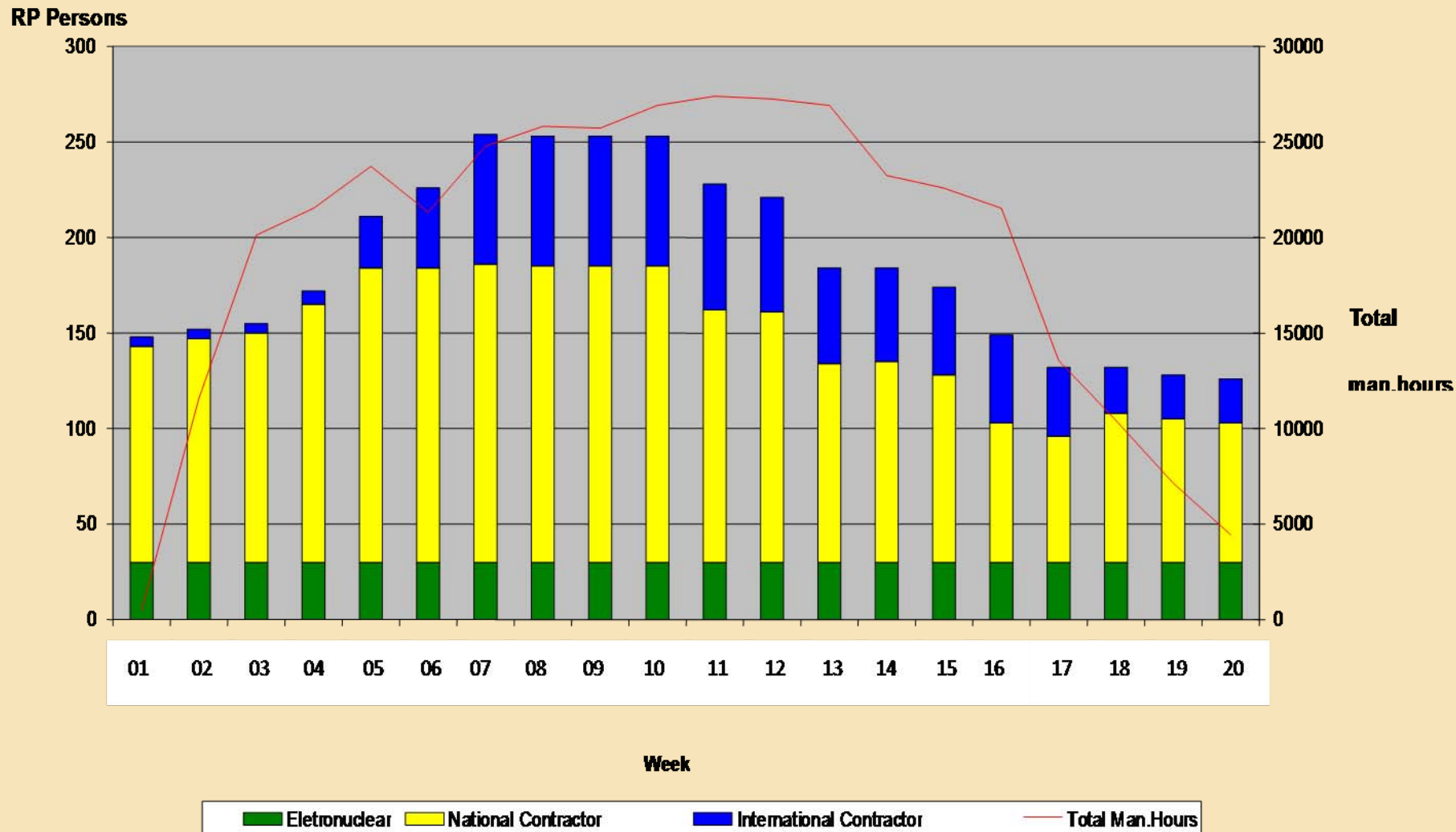


RP ORGANIZATION

Total effort of RP (Angra 1) during SGR

Function	ETN	Brazilian Contractor	International Contractor
Manager	1		
Coordinators	3		
Supervisor	5		8
Senior Technician	12		35
Junior Technician	4		20
Aux. Technician	5	40	
Decon Technician		25	5
Helper		90	
Total	30	155	68

RP ORGANIZATION



TECHNIQUES & TECHNOLOGIES

Emergency lights – red lights were used during high risk evolutions, blinking to warn the workers about the risks in the area, like in the job of radiography, “sand boxes” in the reactor cavity, primary legs cutting out and others.



TECHNIQUES & TECHNOLOGIES

CCTV and Tele-dosimetry, with radio system and pager, made a powerful combination for the online coverage of the jobs in field.



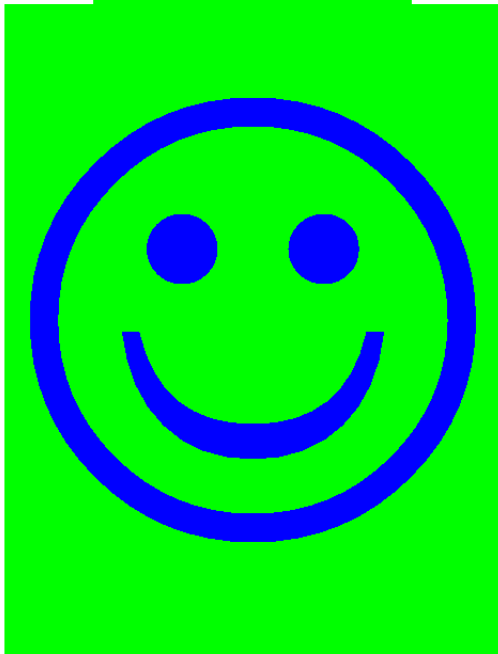
TECHNIQUES & TECHNOLOGIES

Material's Clearance Management – a special team was composed to manage the materials clearance.



TECHNIQUES & TECHNOLOGIES

WAITING AREA



ÁREA DE ESPERA

**CONTROL YOUR TIME -
MINIMIZE YOUR DOSE!**



**CONTROLE SEU TEMPO -
MINIMIZE SUA DOSE!**

**NÃO PERMANEÇA NESTE
LOCAL
DESNECESSÁRIAMENTE!**



**DON'T STAY HERE IF NOT
NECESSARY!**

Colored Postings and Warning Messages – contributed to save doses as the workers remained informed about the areas status.

TECHNIQUES & TECHNOLOGIES

SHIELDING—
not only for
high dose
rates points,
but also to
reduce the
low dose
rates in the
transit areas,
like corridors,
stairs and
stay areas.



TECHNIQUES & TECHNOLOGIES



RP Identification – RP personnel used red jackets in the field.

TECHNIQUES & TECHNOLOGIES

SOURCE TERM REDUCTION

Zinc addition for the RCS during operation

H₂O₂ in the shutdown to achieve less than 0.05 $\mu\text{Ci/gram}$ of Cobalt 58

LEAD SHIELDING

~ 40,000 kg of lead shielding were used

WATER SHIELDING

MOCKUP AND TRAINING

CONTAINMENT OPENING CONTROL



CONTAINMENT OPENING CONTROL



CONTAINMENT OPENING CONTROL



CONTAINMENT OPENING CONTROL



SG TRANSPORTATION

TLD and tele-dosimeters were used to record and control the doses for the personnel during the OSG transportation for the mausoleum.



SITE FACILITIES



SITE FACILITIES



SITE FACILITIES



SG TRANSPORTATION

A complete radiological survey was done, both for doses and contamination.

No events during transportation.



OSG STORAGE

The OSG were stored in a mausoleum, with the low level radwaste produced directly from the SGR.

The RP Team provide the radiological safety for the transportation and secured the route to avoid any unplanned exposure.



RADWASTE

103 boxes with Thermo 12 (asbestos) / 41 boxes sent for mausoleum / 62 boxes were segregated, with the below results:

Total monitored	5,553.90 Kg
Total cleared	5,088.40 Kg – 92%
Total encapsulated	465.50 Kg – 8%
Released boxes	52
Stored boxes in the mausoleum	10

A total of 51 Metallic Boxes with thermal insulation containing asbestos are stored in the mausoleum.

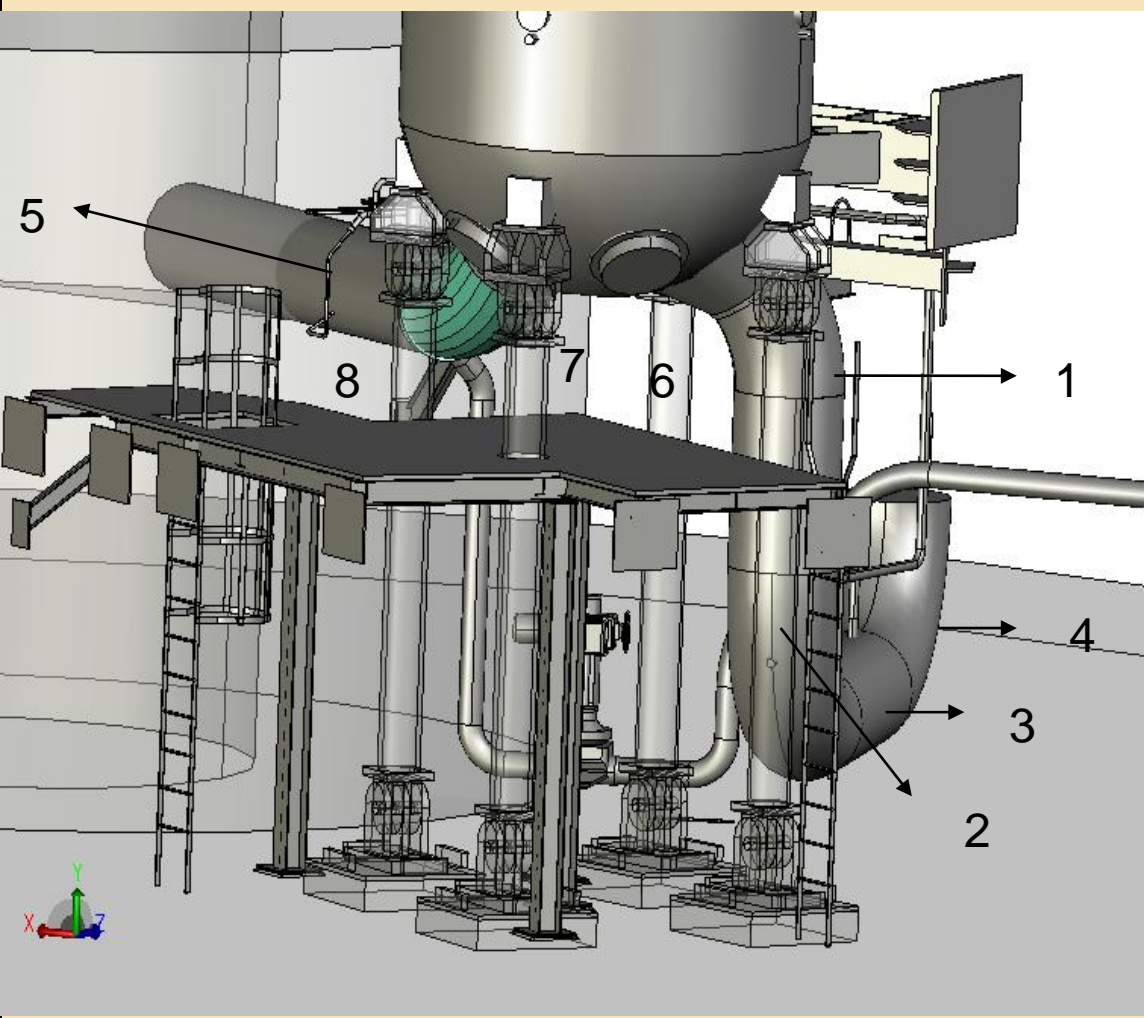
RADWASTE

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TECHNIQUES & TECHNOLOGIES

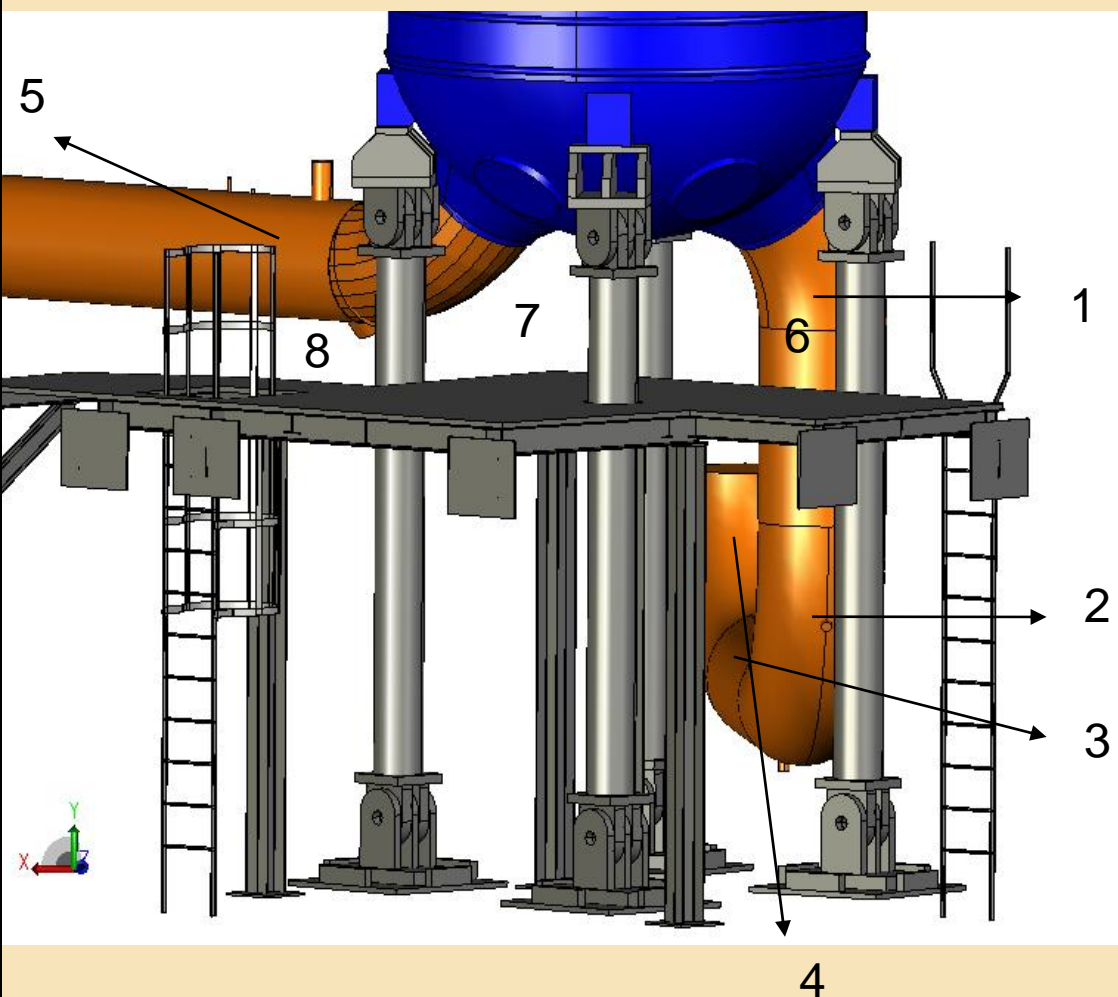
RCS loop 1 – Measurements for shielding efficiency ($\mu\text{Sv/h}$)



Place	W/O Shielding	With Shielding
1	325,0	154,0
2	1950,0	480,0
3	1400,0	449,0
4	330,0	170,0
5	1115,0	520,0
6	55,0	25,0
7	20,0	10,0
8	90,0	20,0

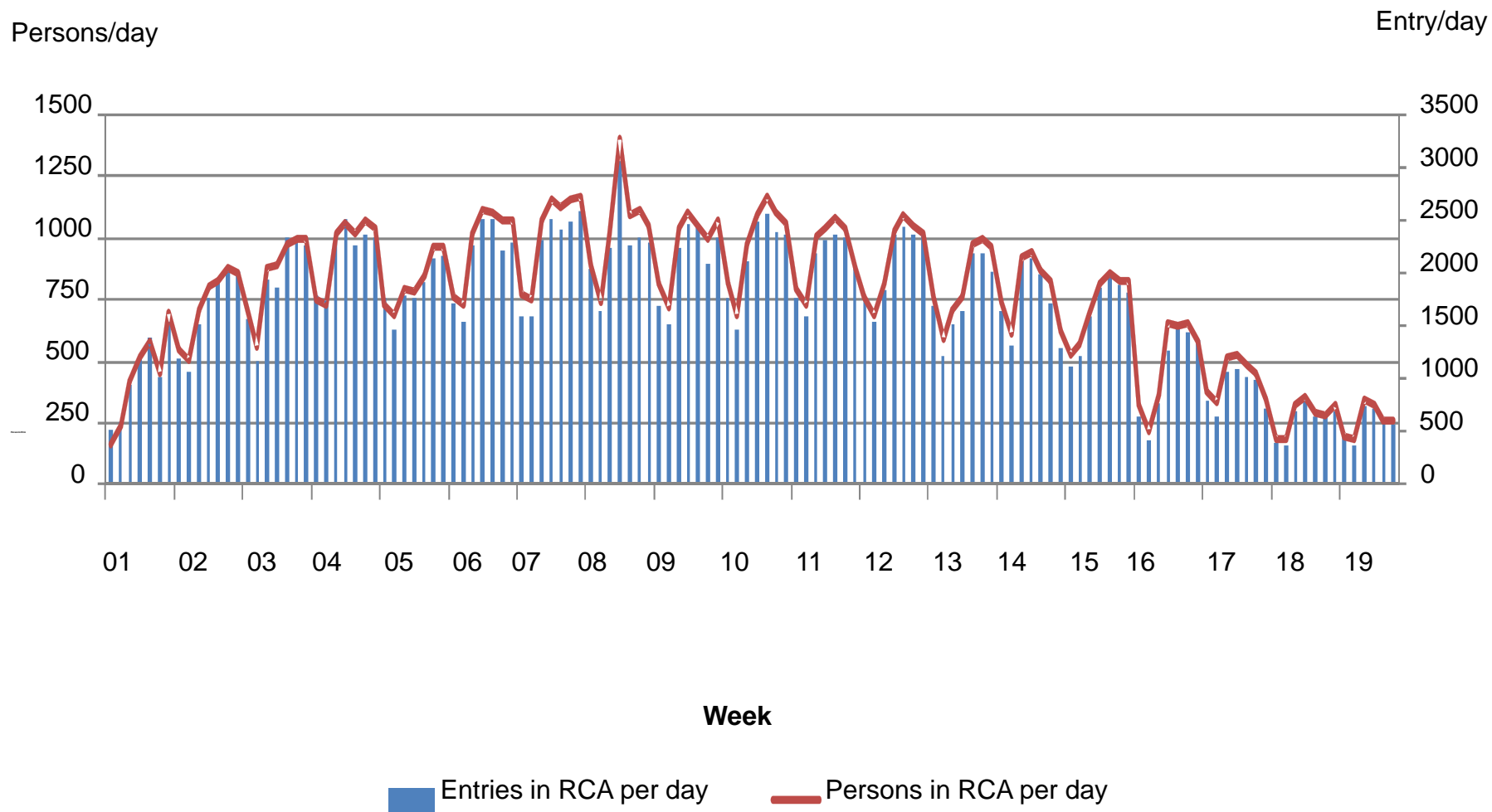
TECHNIQUES & TECHNOLOGIES

RCS loop 2 – Measurements for shielding efficiency ($\mu\text{Sv/h}$)

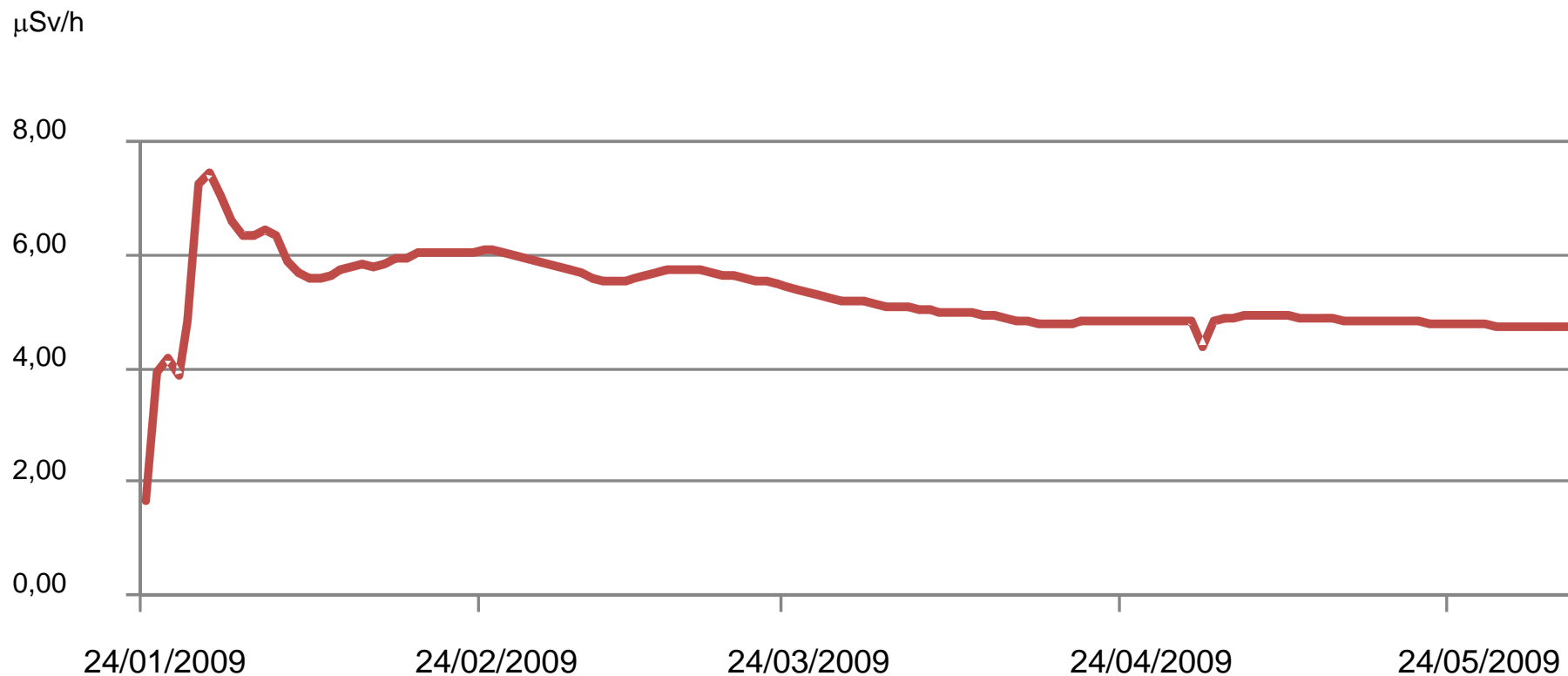


Place	W/O Shielding	With Shielding
1	420,0	210,0
2	1220,0	220,0
3	460,0	280,0
4	300,0	248,0
5	735,0	400,0
6	25,0	16,0
7	15,0	7,0
8	65,0	30,0

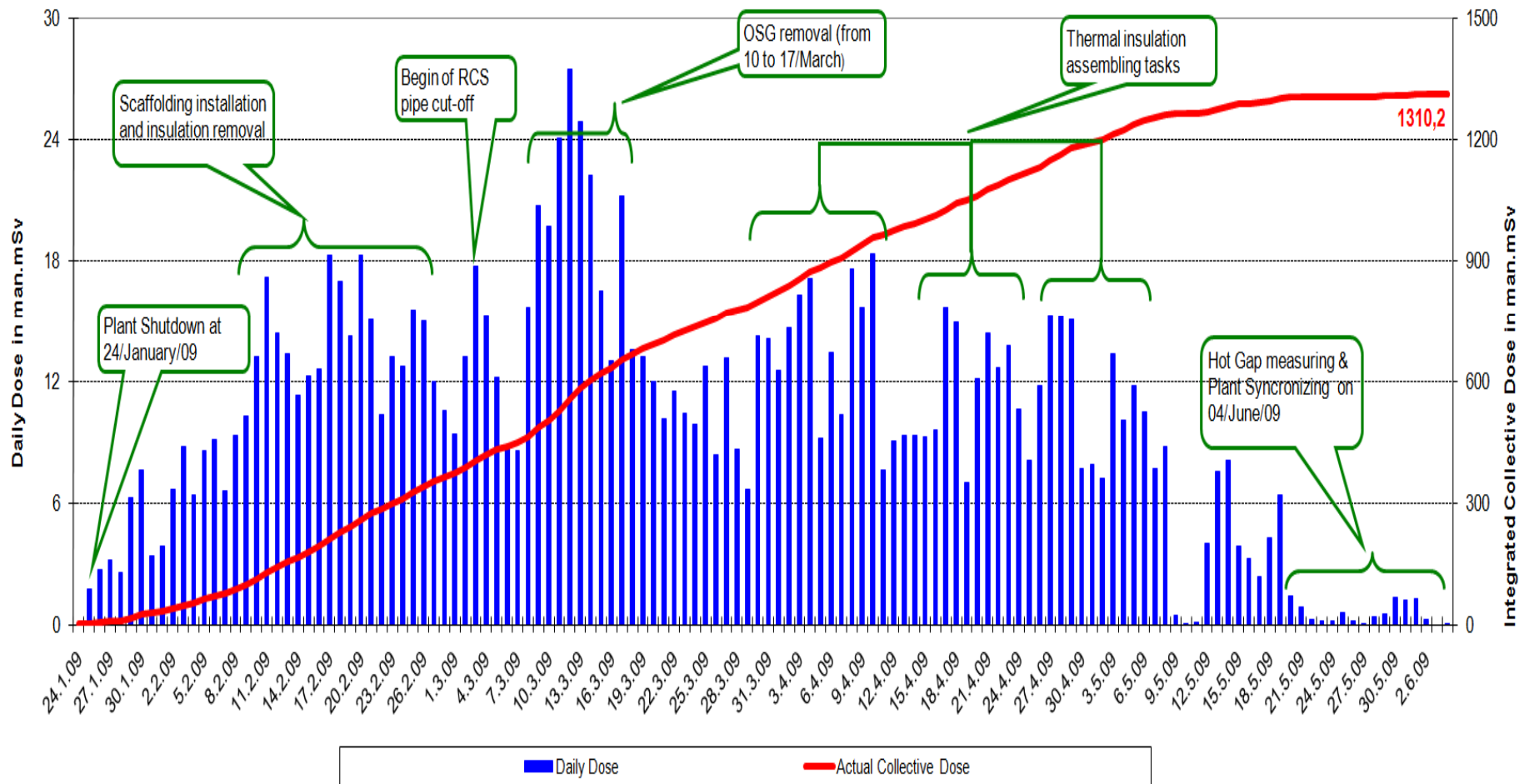
RESULTS



RESULTS

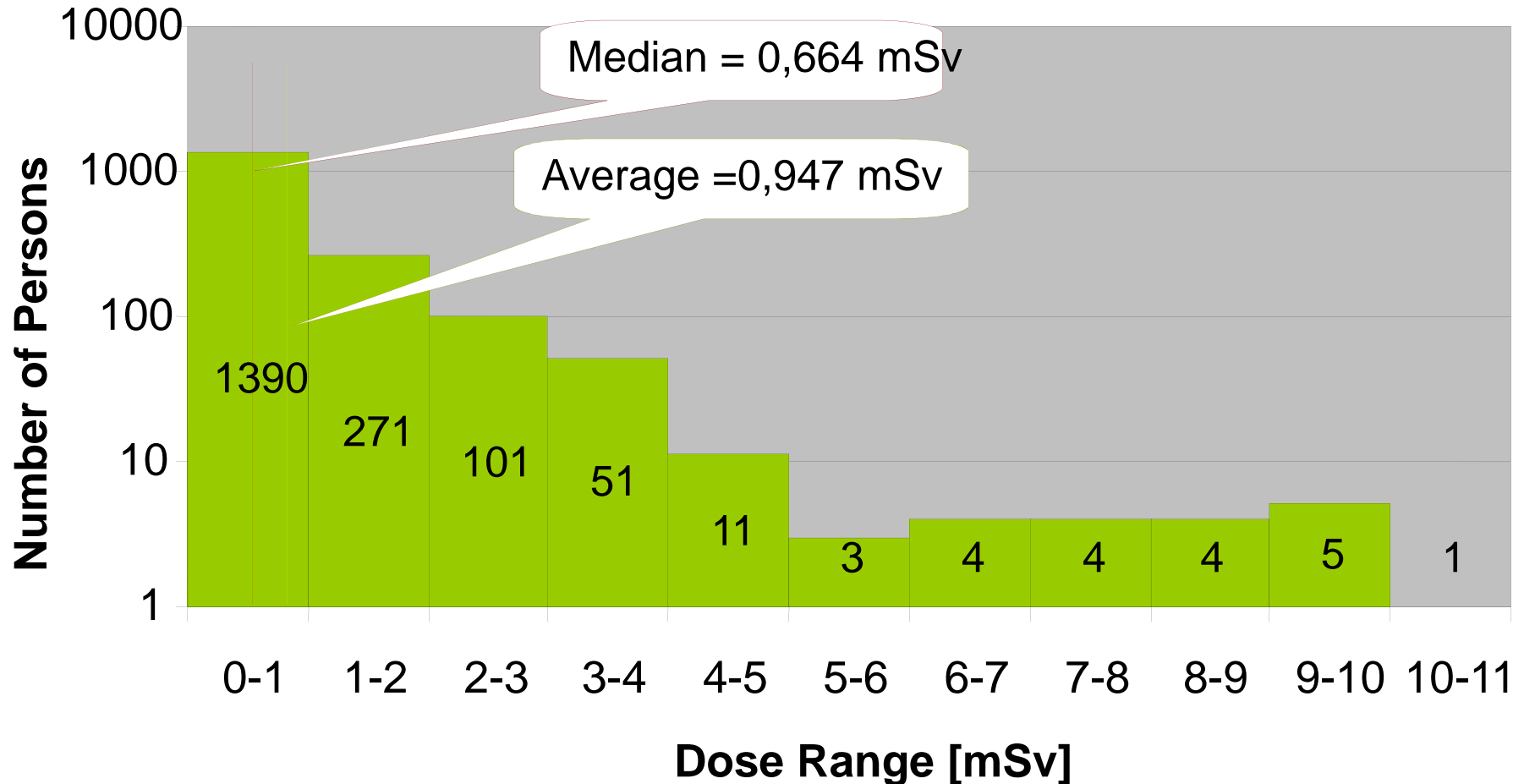


RESULTS

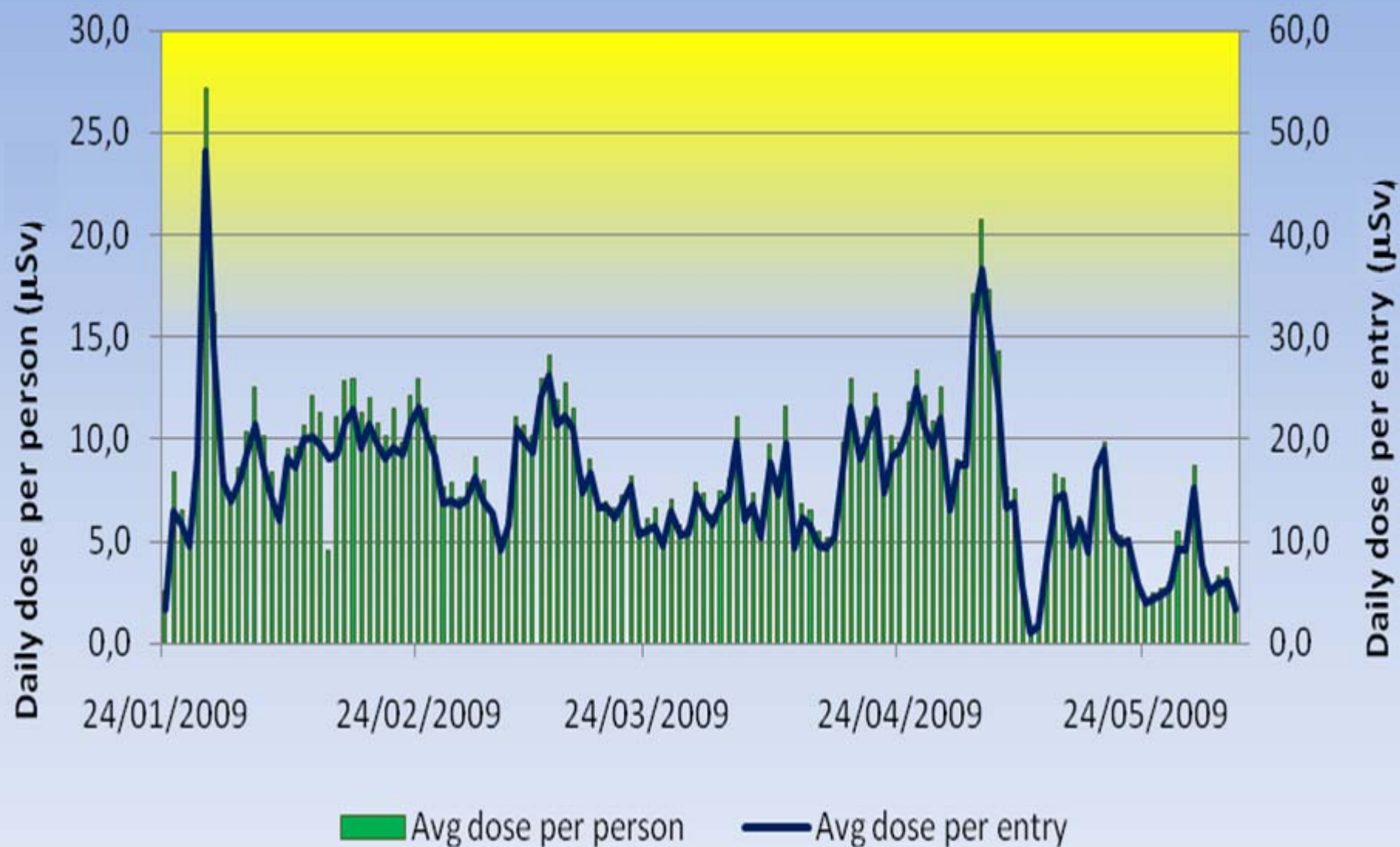


RESULTS

Number of Persons x Dose Range



RESULTS



Thank you!

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