

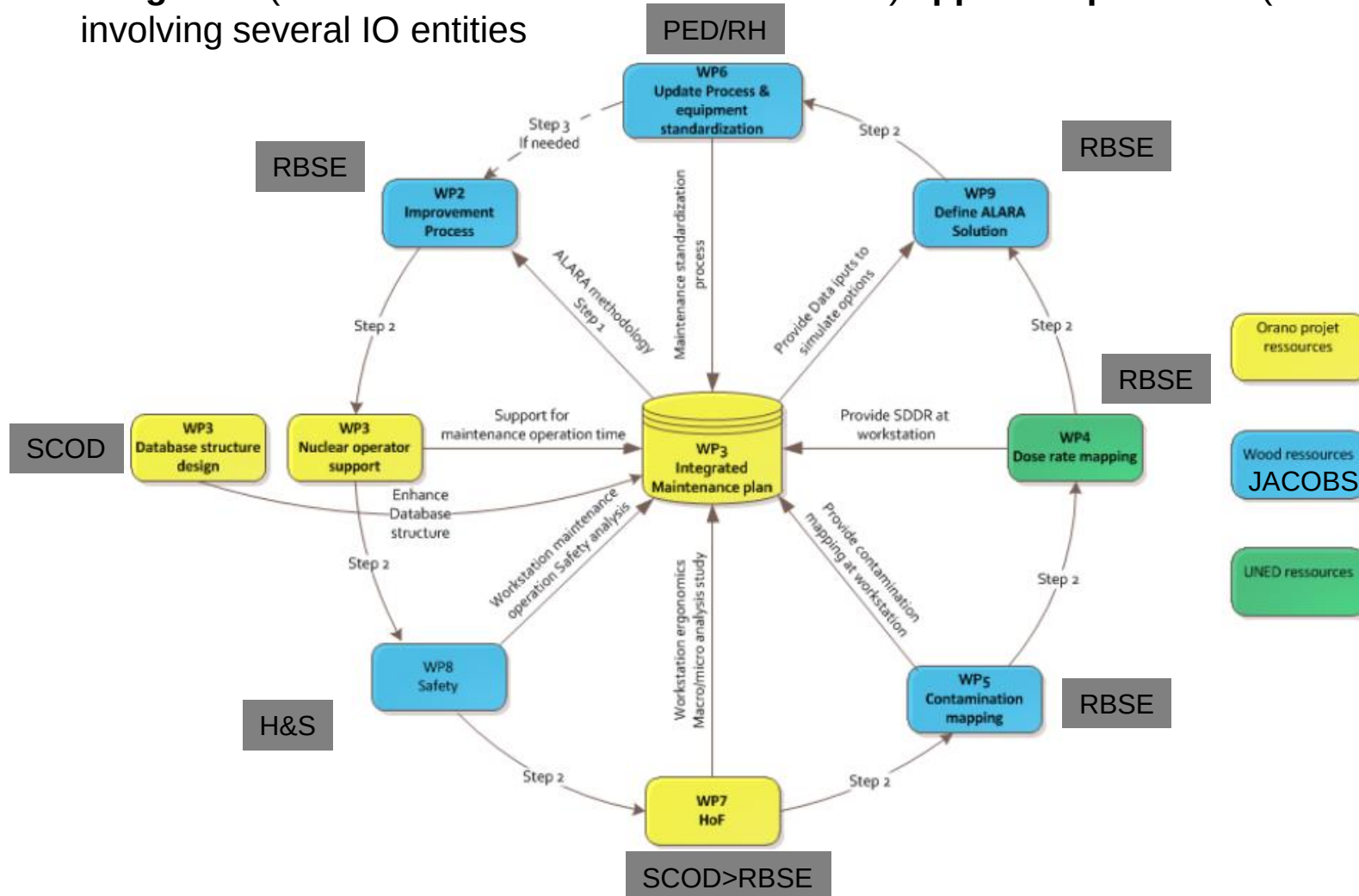
Nuclear Integrated Engineering (NIE)

Final ALARA/ORE status end of 2022

IO NIE team & WORD Consortium
ITER_D_8E6SZW

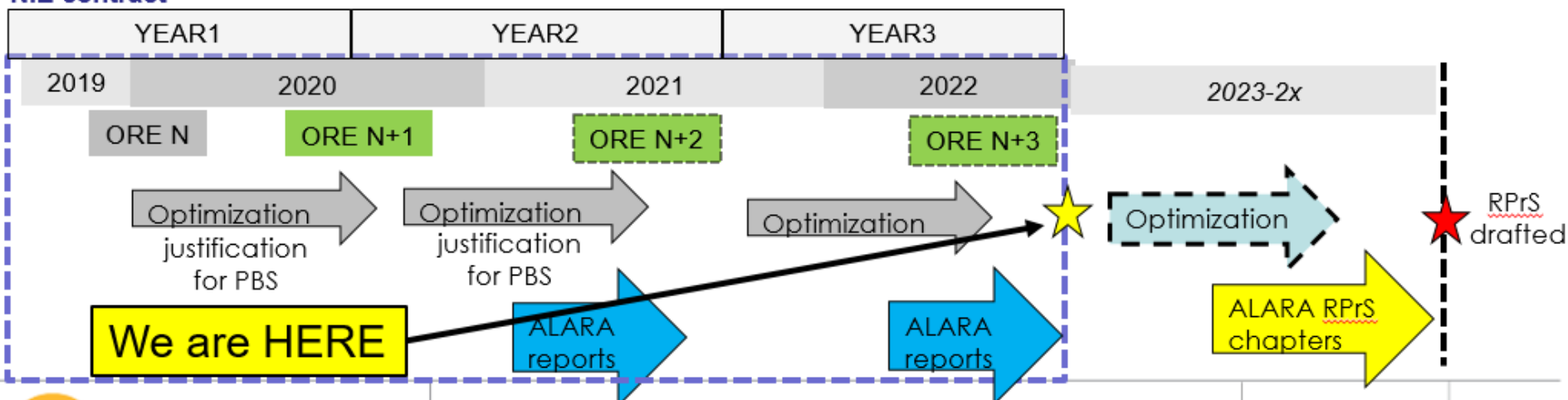
- NIE contract Purpose
- Overall approach
- NIE overview
 - Executive summary
 - NIE ALARA process
 - ITER radiological requirements
 - NIE WP4, WP3
 - Highlight on ACP
 - NIE WP9 – DRM & ORE status (13 areas and perspectives)
 - Global status of DRM and KEY DRM
- RBSE recommendations

- NIE was launched to contribute to ITER ALARA program according to ALARA procedure ([W6655F](#)): **Predictive, formalized and iterative approach**
- Integrated** (several transverse functions/activities) **approach per areas** (multi PBS) involving several IO entities



Global Time Line

NIE contract



Priorities have been identified based on the following criteria:

- ORE contribution (RPrS 2010)
- PBS schedule (maturity of the design/inputs, necessity to check design)
- Importance of the PBS for ITER program (Machine / scientific pg) according to the current baseline (notably RH class 1 systems)

13 representative TOKAMAK areas were analyzed (5 FDR / 8 PDR)

Area	Main system/PBS
UP16	ECH port (PBS52)
UP01	Diag port (PBS55)
EQ08	RH port & Diags ports (PBS55) with vacuum extensions (PBS18/55)
EQ10	Diags ports (PBS55)
EQ15	ICH port (PBS51)
EQ16	TBM port (PBS56)
LP02	Divertor RH port at B1
LP04	Cryo Pumps (PBS31)
LP11	IVVS port (PBS57)
NB Cell (L1/L2)	NB systems (PBS53)
UPPC (L3)	TCWS
LPC (B2)	
DTR (B2)	

13 representatives areas analyzed and used for others areas to give a rough picture for the TOKAMAK

Such approach (tables are mainly green) should give us a good ORE trend at Tokamak level

UPPER PORTS		
No.	Type	Reference ORE Area
U1	Diagnostics Upper	UP-01
U2	Diagnostics Upper w/ DMS	UP-01
U3	Diagnostics Upper	UP-01
U4	NBC	NBC
U5		
U6		
U7		
U8	Diagnostics Upper w/ DMS	UP-01
U9	Diagnostics Upper w/ VV ext	UP-01
U10	Diagnostics Upper	UP-01
U11	Diagnostics Upper	UP-01
U12	ECRH Upper	UP-16
U13	ECRH Upper	UP-16
U14	Diagnostics Upper w/ DMS	UP-01
U15	ECRH Upper	UP-16
U16	ECRH Upper	UP-16
U17	Diagnostics Upper	UP-01
U18	Diagnostics Upper w/ VV ext	UP-01



EQUATORIAL PORTS		
No.	Type	Reference ORE Area
Q1	Diagnostics Equatorial	EQ-10
Q2	Diagnostics Equatorial	EQ-10
Q3	Equatorial RH Port	EQ-08
Q4	NBC	NBC
Q5		
Q6		
Q7		
Q8	Equatorial RH Port	EQ-08
Q9	Diagnostics Equatorial	EQ-10
Q10	Diagnostics Equatorial	EQ-10
Q11	Diagnostics Equatorial	EQ-10
Q12	Equatorial RH Port	EQ-08
Q13	ICRH	EQ-15
Q14	ECRH Equatorial	UP-16
Q15	ICRH	EQ-15
Q16	TBM	EQ-16
Q17	Equatorial RH Port	EQ-08
Q18	TBM	EQ-16



LOWER PORTS		
No.	Type	Reference ORE Area
L1	Cryostat acces flange	N/A
L2	DRHS Port	LP-02
L3	IWS	LP-11
L4	TCP Port	LP-04
L5	IWS	LP-11
L6	TCP Port	LP-04
L7	Cryostat pumping flange	N/A
L8	DRHS Port	LP-02
L9	IWS	LP-11
L10	TCP Port	LP-04
L11	IWS	LP-11
L12	TCP Port	LP-04
L13	Cryostat pumping flange	N/A
L14	DRHS Port	LP-02
L15	IWS	LP-11
L16	TCP Port	LP-04
L17	IWS	LP-11
L18	TCP Port	LP-04



Area studied in NIE



Good approximation from NIE area



No approximation is possible



Similarities but required further investigations

Executive summary

- Objectives was to apply engineering good practice from nuclear industry
- Engineering process with ENG (CIO & PBS) through 32 workshops
- Output are recommended **Dose Reduction Measures (DRMs)** which have been discussed/assessed with PBS for implementation
- Status on Area specific Dose Reduction Measures (DRM):
 - 142 DRM were identified in total
 - 94 DRM were shortlisted for ORE status 2
 - 58 DRM were considered for ORE status 3

NIE overview

NIE ALARA process

2020

Assessment of
baseline
maintenance
activities

SDDR Maps

ORE Status = 1

ITER level ORE ≈ 4200 mSv/LTM (ITER_D_57JTFS)

DRMs derived from good practice, analysis results and collection of PBS ideas.

DRM
Identification
(142 DRMs)

ALARA
Workshops
(94 DRMs)

SDDR Maps

ORE Status = 2

ITER level ORE ≈ 1300 mSv/LTM (ITER_D_57JTFS)

Years 1&2
Year 3

**Updated IO Input
2022 ACP inventory**

**Result in an
increase of
the ORE**

DRM Selection
Workshops
(58 DRMs)

Status N=3
SDDR Maps

ORE Status = 3

ITER level ORE ≈ 6500 mSv/LTM
Note – excluded DRMs may still be 'open'

2022

- [PR5355-R;Defined Requirement]: Where hands-on maintenance activities in port cells and in other locations in the ITER facility requiring human access are performed, **dose rate shall not exceed 100 $\mu\text{Sv/h}$ in yellow zones and 10 $\mu\text{Sv/h}$ in green zones, at 10^6 s (about 12 days) < 100 $\mu\text{Sv/h}$ in yellow zone (hands on)**
- [PR1782-R;Defined Requirement]: To minimize radiation exposure to the workers in port cells (with the exception of the Neutral Beam injectors cell), with the bioshield plug in place, **the dose rate shall be as low as reasonably achievable, and shall not exceed 10 micro-Sv/hr at 24 hours after shutdown**
- [PR2000-R;Defined Requirement]: **ALARA**
- [PR1129-R;Defined Requirement] The **collective annual worker dose**, averaged over the operational life time of ITER, shall be ALARA and in any case shall not exceed an annual target of **0.5 person.Sv**.

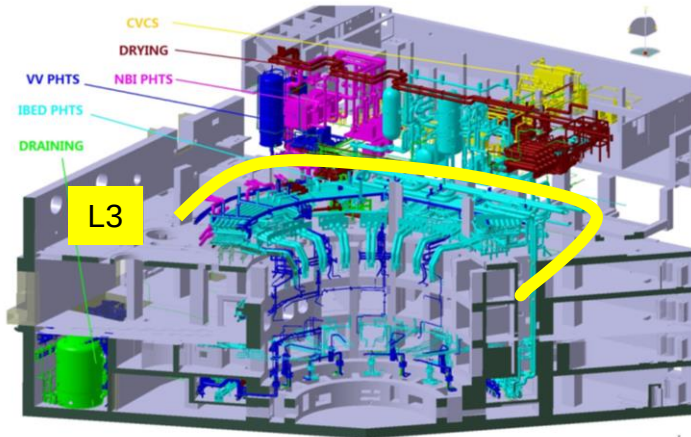
Project received
Deviation Requests
on those
requirements

Table 7-1: Radiological safety objectives

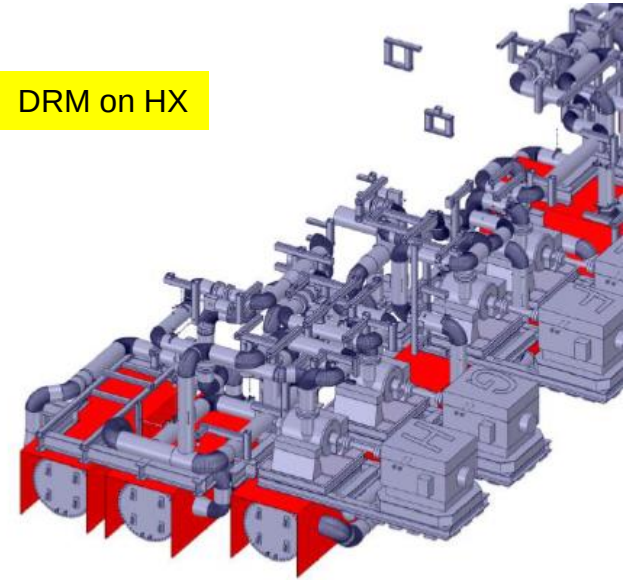
General safety objectives		
	For personnel	For the public and environment
Situations in design basis		
Normal situations	As low as reasonably achievable, and in any case less than: Maximum individual dose <= 10 mSv/yr Average individual dose for workers classified for radiation exposure <= 2.5 mSv/yr	Releases less than the limits authorised for the installation Impact as low as reasonably achievable and in case less than: <= 0.1 mSv/yr
Incidental situations	As low as reasonably achievable and in any case less than: 10 mSv per incident	Release per incident less than the annual limits authorized for the installation. ≤ 0.1 mSv
Accidental situations	Take into account the constraints related to the management of the accident and post-accident situation	No immediate or deferred counter-measures (confinement, evacuation) < 10 mSv No restriction of consumption of animal or vegetable products
Situations beyond design basis		
Hypothetical events	No cliff-edge effect; possible counter-measures limited in time and space	

• RPrS requirements

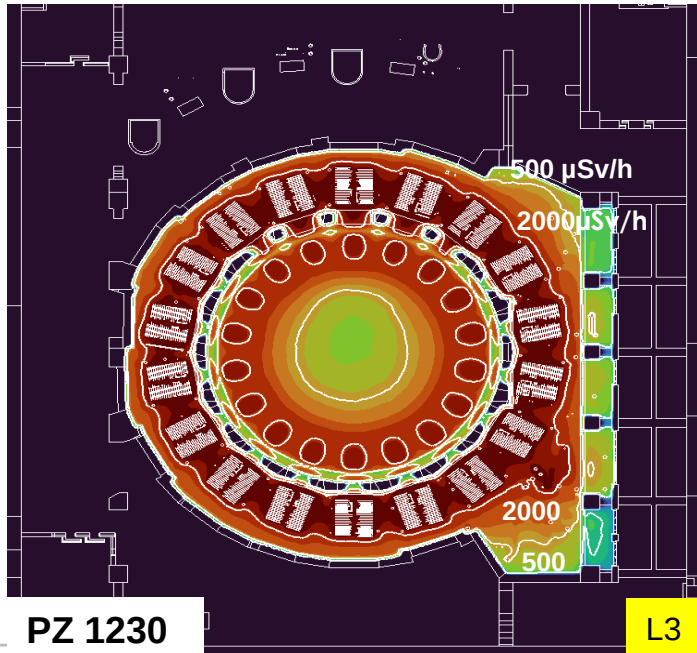
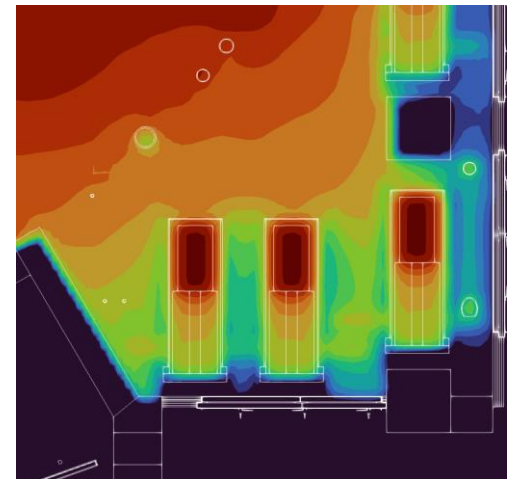
SDDR maps – Upper Pipe chase



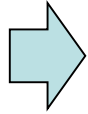
DRM on HX



DRM impact on SDDR around HX



- Activated Corrosion Products (ACP) is well known to be responsible of workers dose in NPP (80% in EDF PWR). In ITER, Very large Cooling systems (>40 km of piping, >50 pieces of equipment, >3000 valves) with water under very neutrons flux ($1e^{12}$ n.cm²s⁻¹)



Primary Importance to understand the ACP source term (origin, conservatism), the best ways to reduce ACP contribution including lesson learned from Fission industry

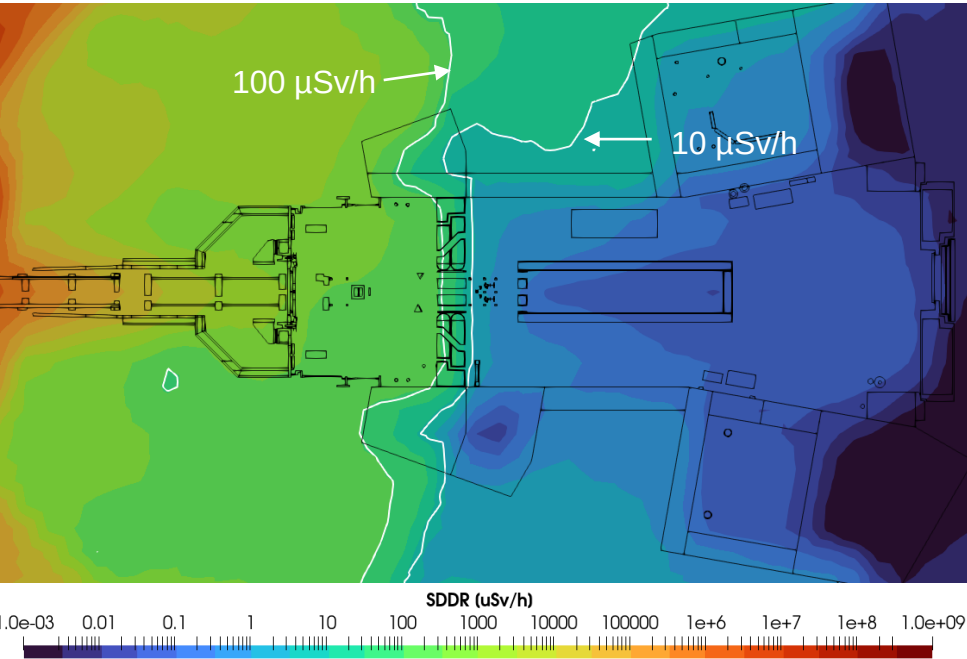
- OSCAR code is a french code developped by CEA-EDF-FRAMATOME. CEA customize it for fusion: OSCAR-FUSION. OSCAR was used to assess ACP inventory for RPrS (accident analysis)
- In 2022, RBSE launched an expert contract with CEA to recheck all the input in order to be more robust with the proposal to continue workshops with EDF/FRAMATOME/ORANO/EUROFUSION/F4E

Regions	Region Description	Wet Surface area [m ²]	2019 [TBq]	2022 [TBq]	Ratio 2022/2019Rev
In Flux	In-flux	7675	261	557.8 EoL 495.2 EoL+Baking	~ 2
Out of Flux	Out of flux	15958	2.59	12.65 EoL 12.8 EoL+Baking	~ 4
Jungle Jim return	Out of flux	1154	0.45	3.74	~ 8

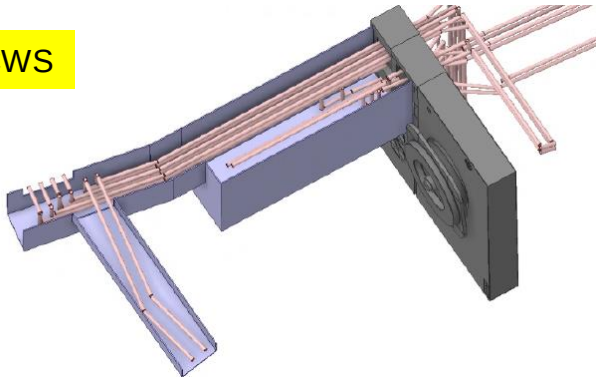
Co60 is the main driver

Recommendations from WG2 on DRM were considered

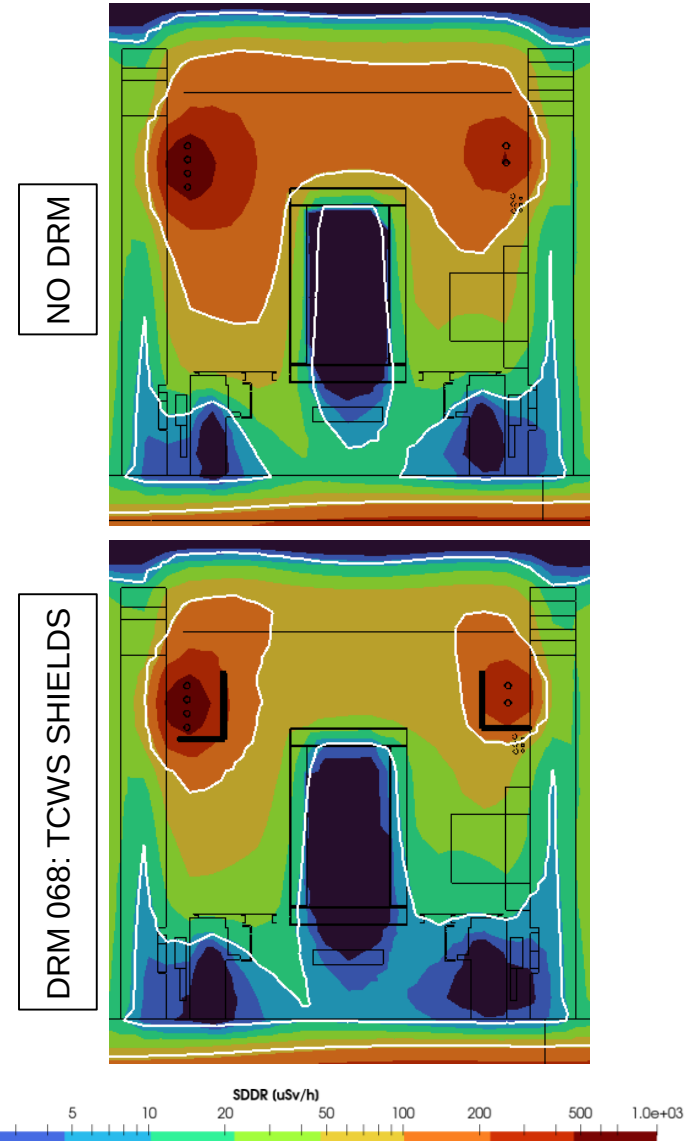
SDDR maps (**PLASMA**) – Lower Port #02



DRM on TCWS

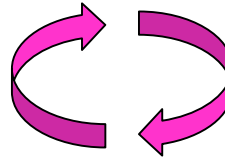
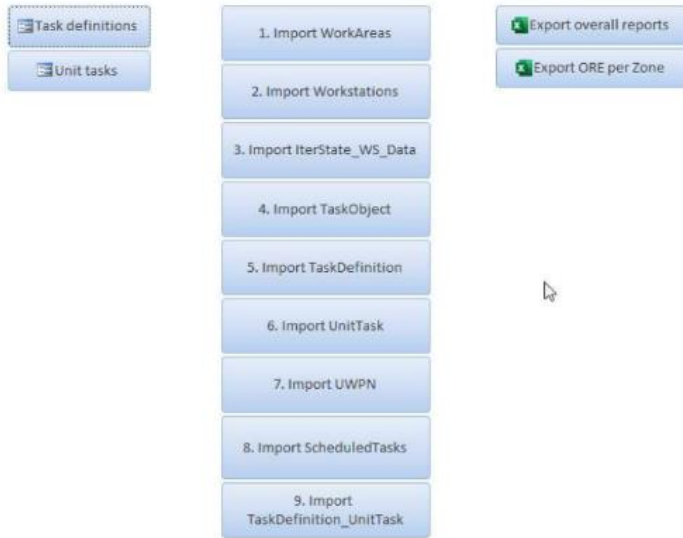


SDDR maps (**ACP**) – Lower Port #02



Inspection/preventive (scheduled) maintenance/reconfiguration is captured to assess ORE – Corrective is identified too

ITER Database



PBS15 maintenance activities v1.0 (ITER_D_5UDCVT)
 PBS17 maintenance activities v1.0 (ITER_D_5UDJPC)
 PBS18 maintenance activities v1.0 (ITER_D_5YH6FT)
 PBS23 maintenance activities v1.0 (ITER_D_5ZGXTV)
 PBS24 maintenance activities v1.0 (ITER_D_68ZKWU)
 PBS26 maintenance activities v1.0 (ITER_D_6JEMUC)
 PBS31 maintenance activities v1.0 (ITER_D_7JTUD7)
 PBS32 maintenance activities v1.0 (ITER_D_7P7HFW)
 PBS34 maintenance activities v1.0 (ITER_D_7V7793)
 PBS41 maintenance activities v1.0 (ITER_D_7WNQFL)
 PBS51 maintenance activities v1.0 (ITER_D_7WNVY6)
 PBS52 maintenance activities v1.0 (ITER_D_7WNWNA)
 PBS53 maintenance activities v1.0 (ITER_D_7WNXUK)
 PBS55 maintenance activities v1.0 (ITER_D_7WNXMX)
 WP-B.D2 Input Data package fir PDR v1.0 (ITER_D_5PNP4V)
 PBS57 maintenance activities v1.0 (ITER_D_7WNYWW)
 PBS62-64-65 maintenance activities v1.0 (ITER_D_7WNZRH)

WP3 MS Access ITER Maintenance Database

PBS inspection and maintenance reviewed by IO (SCOD) + Orano from nuclear operator perspective (Orano feedback)

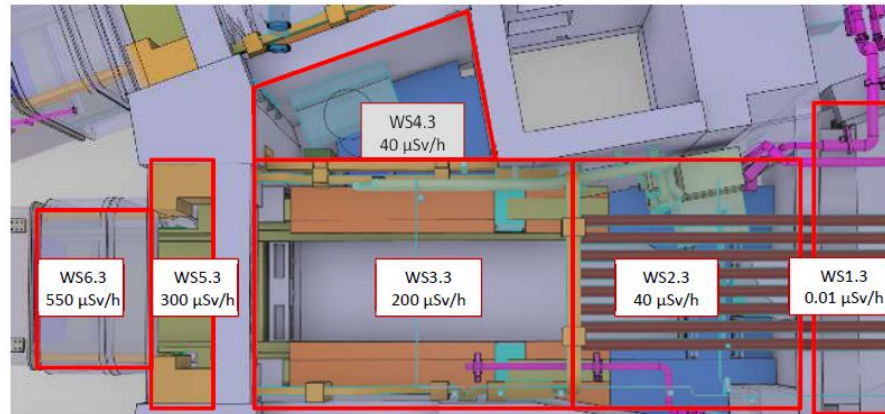


Figure 14: UP#16 STEP 1 SDDR Config 3 (no shielding cabin configuration)

WP3: Wi config / SDDR for the 13 representative areas (assessed from WP4 output)

Recommendations from WG1 on maintenance was considered

PBS	Task number	Task definition	Frequency/Event	ORE man.μSv STEP 1	ORE man.μSv STEP 2	IO document reference
32	29	UP16 - Detriation pipe inspection - To be confirmed	LTM	TBD/TBC	TBD/TBC	
55	30	UP16 - Coils Upper - IVC feedthrough Inspection by endoscope (16 hours)	LTM	59,859	N/A in vessel	[85] task cancelled following meeting [100]
44	31	UP16 - ELM SIC cable tray inspection ? - To be confirmed (*)	LTM	TBD/TBC	TBD/TBC	
44	32	UP16 - VS SIC cable tray inspection ? - To be confirmed (*)	LTM	TBD/TBC	TBD/TBC	
62	33	UP16 - Bio Shield Plug opening	Failure	N/A	N/A	Assumption
61	34	UP16 - Contaminated Water drainage Inspection (*)	LTM	TBD/TBC	TBD/TBC	
62	35	UP16 - Fire protection inspection	LTM	TBD/TBC	TBD/TBC	
61	36	UP16 - Building Concrete and Emergency Power Supply	TBD/TBC	TBD/TBC	TBD/TBC	
62	37	UP16 - HVAC - relief panel maintenance	LTM	19	9	Assumption
62	38	UP16 - Demineralised Water valves inspection	LTM	20	4	Assumption
62	39	UP16 - Nitrogen valves inspection	LTM	257	4	Assumption
52	40	UP16 - Simplified polarized and WG and expansion unit inspection - Ex vessel waveguide inspection	LTM	261	33	[15] [7]
52	41	UP16 - Diamond windows inspection	LTM	271	9	[15] [7]
52	42	UP16 - Isolation valve visual inspection (ceiling)	LTM	266	9	[15] [7]
52	43	UP16 - Replacement of isolation valves (ceiling)	Corrective	434	148	[15] [7]

Task number	Main tasks contributor	ORE man.μSv	Percent
50	UP16 - VV Upper Port Extension Inspection - ESPN	3,072	21.5%
47	UP16 - VV Sealing Flange - Lip seal In-Service Inspection	2,592	18.2%
44	UP16 - Cooling line - ESPN - Internal & External visual examination of all visible areas including welded joints	180	1.3%
Total ORE man.mSv - STEP 2		7.4	100.00%
Total ORE man.mSv - STEP 1		136.34	

• Corrective tasks (see § 5.1.2):

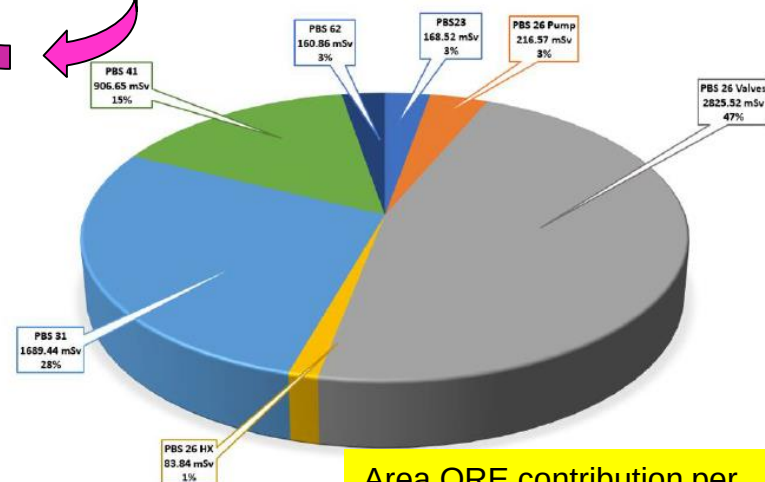
Task number	Main tasks contributor	ORE man.μSv	Percent
53	UP16 - Replacement of insulation break	7,828	26.7%
55	UP16 - Replacement of feedthrough	5,562	18.8%
23	UP16 - Mitre bend replacement (*)	5,520	18.8%
10	UP16 - Replacement of electrical feedthrough (*)	4,492	15.3%
11	UP16 - Adaptation of jumpers for degraded mode of operation (*)	2,026	6.9%
54	UP16 - Replacement of thermocouples	1,381	4.7%
8	UP16 - In-vessel waveguides flange bolting	1,228	4.2%
Total ORE man.mSv - STEP 2		29.4	100.00%
Total ORE man.mSv - STEP 1		60.526	

WP3 area inspections & maintenance tasks ORE per task

	LTM 6		LTM 7		LTM 8		LTM 9		LTM 10		LTM 11	
	STEP1	STEP3	STEP1	STEP3	STEP1	STEP3	STEP1	STEP3	STEP1	STEP3	STEP1	STEP3
EP#10 - ORE for preventive maintenance every LTM	13.78	7.2	13.78	7.2	13.78	7.2	13.78	7.2	13.78	7.2	13.78	7.2
EP#10 - ORE for preventive maintenance every LTM	4.47	4.82			4.47	4.82			4.47	4.82		
EP#10 - ORE for preventive maintenance every LTM	0.42	0.53										
EP#10 - ORE for preventive maintenance every LTM					1.71	1.58						
EP#10 - ORE for preventive maintenance every LTM							0.43	0.53				
EP#10 ORE per LTM for preventive maintenance mSv - STEP 3	12.57		7.22		13.62		7.75		12.04		7.22	
EP#10 ORE per LTM for preventive maintenance mSv - STEP 2	14.01		11.2		14.01		11.51		13.7		11.2	
EP#10 ORE per LTM for preventive maintenance mSv - STEP 1	18.67		13.78		19.96		14.21		18.25		13.78	

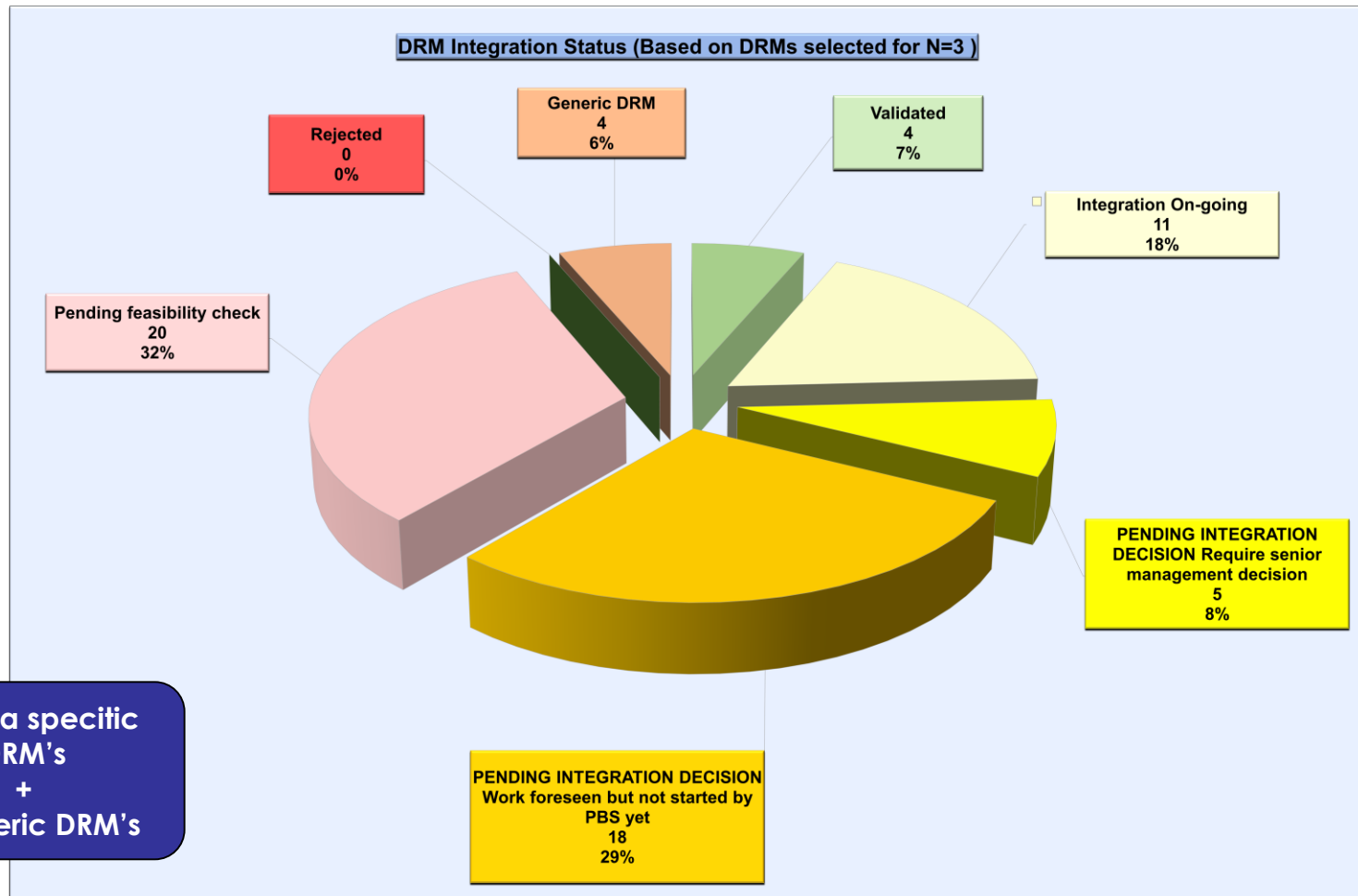
ORE per aera /per LTM

Area ORE contribution per PBS

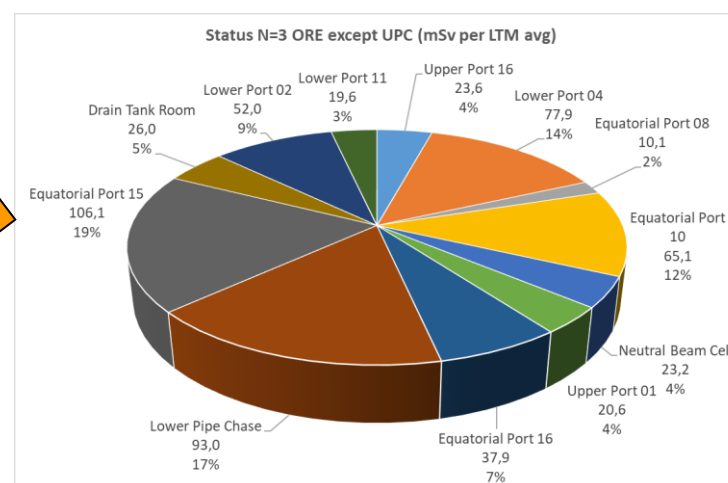
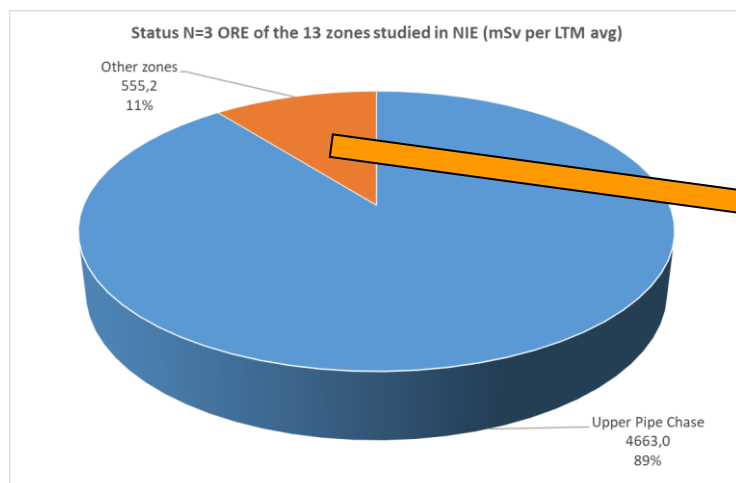


Area ORE contribution per PBS contribution pie chart

Current DRM Integration status across all areas (62 DRM status ORE 3)



Area	Status N=1 ORE Baseline (mSv per LTM on average)	Status N=2 ORE Improved (mSv per LTM on average)	Status N=3 ORE 2022 (mSv per LTM on average)
Upper Port 16	136,4	7,4	23,6
Upper Pipe Chase	1386,4	505,8	4663,0
Lower Port 04	99,7	45,0	77,9
Equatorial Port 08	16,5	12,6	10,1
Equatorial Port 10	51,6	26,2	65,1
Neutral Beam Cell	70,3	9,9	23,2
Upper Port 01	17,4	5,5	20,6
Equatorial Port 16	36,1	14,0	37,9
Lower Pipe Chase	102,1	8,4	93,0
Equatorial Port 15	148,0	0,7	106,1
Drain Tank Room	37,9	10,9	26,0
Lower Port 02	83,2	43,1	52,0
Lower Port 11	38,8	8,8	19,6



PIM-168

Based on those 13 representative areas, it is possible to assess the global ITER TOKAMAK ORE (No L4/L5, B14 or mode 0/2...and no HCC)

Upper ports + Equatorial ports + Lower ports + UPPC+LPC+DTR*

3 Lower ports (red) + L4/L5 floors areas not included

Area	Status N=1 ORE (mSv)							Status N=2 ORE (mSv)							Status N=3 ORE (mSv)						
	Average	LTM6	LTM7	LTM8	LTM9	LTM10	LTM11	Average	LTM6	LTM7	LTM8	LTM9	LTM10	LTM11	Average	LTM6	LTM7	LTM8	LTM9	LTM10	LTM11
Upper Ports Sub-Total*	720	728	713	726	717	725	713	84	87	82	89	83	85	82	300	314	282	321	282	321	282
Equatorial Ports Sub-Total*	793	702	672	1341	674	700	672	205	145	129	551	131	143	129	623	496	467	1342	470	493	467
Lower Ports Sub-Total	1080	1084	1471	1072	1282	1112	463	452	369	892	366	424	362	299	741	725	1279	721	490	766	465
NBC	70	68	65	92	65	68	65	10	9	7	21	7	9	7	23	20	19	40	19	20	19
UPC	1386	826	826	2023	1310	2506	827	506	355	355	442	720	807	355	4663	3729	3713	3919	6349	6553	3715
LPC	102	35	35	35	235	235	35	8	4	4	4	31	4	4	93	26	26	26	227	227	26
DTR	38	49	29	50	25	49	26	11	14	8	15	6	14	7	26	34	19	35	17	34	18
TOTAL (mSv)	4190	3491	3811	5339	4307	5394	2800	1276	983	1476	1487	1401	1424	883	6469	5344	5806	6403	7855	8415	4993

4200 mSv/LTM

1300 mSv/LTM

6500 mSv/LTM

~3250mSv/year

Reminder, objective is 500 mSv/year collective dose. ALARA is MANDATORY for ITER Time for DRM decision !

- Outcomes:

- ALARA effort is formalized though NIE in addition to PBS effort: **101 DRM are considered valid**,
- **ORE at Tokamak level is above 6500 men.mSv/LTM** (based on input + batch of 58 DRM considered that could be integrated) > **~3250 men.mSv/year**
- **Very high dose rate due to ACP around TCWS** (UPPC: 4663 men.mSv/LTM) and **current average Port cell ~49 men.mSv/LTM** → **ALARA effort to be continued**
- **Despite ALL DRM identified and selected, we still need important optimization**
- ALARA management tools available to move forward: DRM forms, tracker, Maintenance database, MCNP models...
- End of NIE contract → Nov. 2022

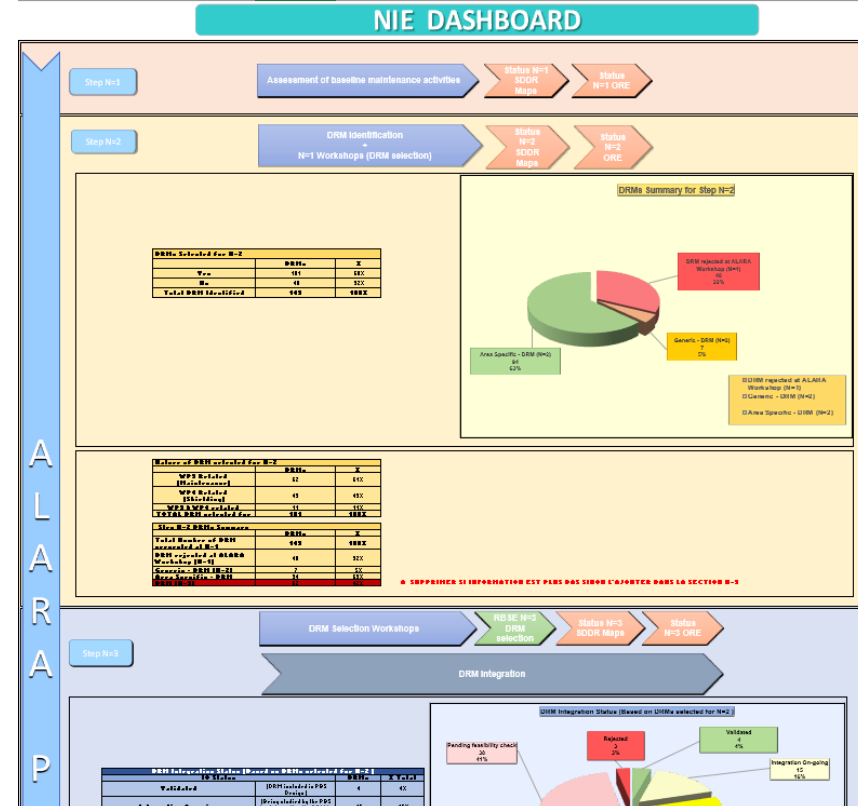
- Recommendations:

- Set up quickly a **specific ACP/TCWS team with PBS26 + SCOD + RBSE** to promote appropriate DRM (operation/design) + CEA expert contract & workshops
- **Optimization alternative through Scientific program rationalization ?**
 - reduction of neutrons productions/campaign optimization
 - Rationalization of machine configuration (optimization of PC equipped / DT campaign)
- Perform transverse Safety engineering with **empowered decision making body + Engineering coordination to study DRM → baseline DRM through PCR**

BACK UP

Dashboard

- Output of the ALARA Process
 - DRM Forms
 - Found in IDM folders;
 - [6W7GWT](#)
 - [4KKR42](#)
 - DRM Tracker
 - [6ECUV5](#)
 - Dashboard to monitor progress of the integration of the DRM within ITER baseline (TBC)
 - ACCESS DATABASE gathering all PBS inspection/maintenance input



DRM Form Presentation

Dose Reduction Measure (DRM) Proposal Form (3SBDPU v2.0) (current)

DOSE REDUCTION MEASURE (DRM) PROPOSAL FORM			
orano UNED Jacobs Dose Reduction Measure (DRM) Proposal Form Form Reference ITER_D_3SBDPU v1.0 Nuclear Integrated Engineering (NIE) Contract IG/CT/4300001948 Page: 1 / 3			
DESCRIPTION			
ID Number	ID number from tracker	Applicable Area(s)	E.g. EQ-11
DRM Title	Insert title of the DRM here		
Jacobs Engineering Ref	Insert Jacobs Engineering DRM reference here		
Background			
Explain context and nature of the problem – i.e. high SDDR in a particular workstation due to gap in shielding, or a particular task takes a very long duration, contributing highly to the area ORE for example.			
Description of DRM Proposal			
Description of the DRM at a concept level, supported with images where possible. Integration issues or drawbacks should not be stated here; they will follow in later sections.			
Applicable Tasks			
List task numbers and titles, consistent with WP3		SIC/PIC Components?	
1 – Replacement of component A		☐	
2 – Calibration of component B			
BENEFIT			
Dose Reduction in Isolation (mSv)	12.6 mSv	Dose Reduction Score (1-5)	4
Basis of Dose Reduction Estimate		Other Benefits	
Explain how this estimate of the dose reduction was derived, including key assumptions.		Briefly note other benefits to ITER from this DRM which are unrelated to dose reduction.	
COST			
Costs			
Qualitative or semi-qualitative description of all costs and disadvantages associated with the implementation of this DRM. These may include:			
- Financial cost - Incompatibility with current requirements - Integration problems - Increased complexity - Conventional safety risks - Any other disadvantages			

DOSE REDUCTION MEASURE (DRM) PROPOSAL FORM	
orano UNED Jacobs Dose Reduction Measure (DRM) Proposal Form Form Reference ITER_D_3SBDPU v1.0 Nuclear Integrated Engineering (NIE) Contract IG/CT/4300001948 Page: 2 / 3	
Project Impact Score (0-4)	
2	
INTEGRATION	
Integration Issues	
Describe here all integration issues. Include issues such as potential clashes, displacement of other components, civil loads, encroachment on human passage and the current state of the design and manufacturing (potential for rework).	
DRM required for which phase;	
☐ First Plasma ☐ PFPO-1 ☐ PFPO-2 ☐ FPO (DT)	
Describe any other potential transversal issues such as changes to the fire loading in an area, or changes to area classification.	
List the key points for further study, to demonstrate the feasibility or otherwise of this DRM.	
Alternative to implementing this DRM	
Consider alternatives to implementing this DRM as described above, if any. Alternative approaches should take into consideration the integration constraints mentioned in the section above.	
Affected PBS	
List the PBS affected by this change	
PCR Required?	
☐	
PBS INPUT (MAIN PBS ONLY)	
PBS ID	
e.g. 55 or 55.U4	
TRO Name	
Jean Dupont	
PBS Comments	
Any comments regarding the feasibility, effectiveness or implementation of this DRM.	
PBS ID	
e.g. 55 or 55.U4	
TRO Name	
Jean Dupont	
PBS Comments	
Any comments regarding the feasibility, effectiveness or implementation of this DRM.	
DECISION	
Recommended?	Lead Party for Implementation
☐	PBS 55
Basis for Decision	
Briefly explain the basis for recommending this DRM or not. Explain any conditions attached to this recommendation.	
ALARA Potential Score (0-20)	
8 (product of Dose Reduction Score and Project Impact Score)	

DOSE REDUCTION MEASURE (DRM) PROPOSAL FORM	
orano UNED Jacobs Dose Reduction Measure (DRM) Proposal Form Form Reference ITER_D_3SBDPU v1.0 Nuclear Integrated Engineering (NIE) Contract IG/CT/4300001948 Page: 3 / 3	
IO DRM INTEGRATION IN DESIGN BASELINE	
Status	☐ Validated ☐ Pending actions ☐ Rejected
Insert workshop's minutes of meeting IDM link.	
Pending actions to be closed-out before integration decision	Insert actions to be closed-out before integration decision based on the action tracker.
Integration Implementation	E.g. On-hold until actions closed out Senior Mgt validation / PCR / DR
RBSE ALARA STUDY N=3	
RBSE Decision for ALARA study N=3	☐ Yes ☐ No
Comments of the RBSE final decision	Insert comments of the RBSE final decision based on workshops.

ITER D 6ECUV5 - DRM Tracker

ID	Title	DRM Proposal Form	Dose Reduction (Calculated based on N=1 status). mSv	Recommended for Status N=2?	WP3 related	WP4 related	RBSE final position for N=3	IO Status	Integration implementation	Justifications
A7	Implementation of shielding cabin	https://user.iter.org/default.aspx?uid=7EA	86.8 man.mSv (based on FDR concept) 104.3 man.mSv (with optimisations)	Yes	No	yes	Yes	Pending Integration Decision	Work foreseen but not started by PBS yet	Proposal developed by PBS-52. Not yet baseline but it is foreseen to raise a PCR.
A8	Optimisation of shielding cabin and	https://user.iter.org/default.aspx?uid=7EA	86.8 man.mSv (based on FDR concept) 104.3 man.mSv (with optimisations)	Yes	No	yes	Yes	Pending Integration Decision	Work foreseen but not started by PBS yet	Proposal developed by PBS-52. Not yet baseline but it is foreseen to raise a PCR.
A28	Chemical cleaning of the IBED HX	https://user.iter.org/default.aspx?uid=7N2	506	Yes	Yes	Yes	No	Pending Feasibility Check	PBS is currently checking feasibility.	Benefit not visible since most of the maintenance will now be classed as corrective rather than preventive. Technical feasibility not yet studied. Waste streams (liquid, gas, solid) not defined, nor their treatment. ESPN inspections to be defined - base preventive ORE uncertain.
A29	IBED HX top shielding	https://user.iter.org/default.aspx?uid=7P7	388	Yes	No	Yes	Yes	Pending Feasibility Check	PBS is currently checking feasibility.	There is an existing mass allowance of 10 tonnes per HX for this shielding, although an integration study will be necessary.
A30	IBED HX side shielding	https://user.iter.org/default.aspx?uid=7P7	388	Yes	No	Yes	Yes	Pending Feasibility Check	PBS is currently checking feasibility.	There is an existing mass allowance of 10 tonnes per HX for this shielding, although an integration study will be necessary.
024	Replace Lipseal with MGsf	https://user.iter.org/?uid=4Y3G5	EQ-16 : 7.4 EQ-15 : 147.6 LP-02 : 6.3 LP-11 : 2.2	Yes	Yes	No	NO	Pending Integration Decision	Require Senior Management decision	Transverse issue requiring management decision.
032	Chemical cleaning of headers	https://user.iter.org/?uid=57JUBG	138 (during LTM 9 and 10)	Yes	Yes	Yes	No	Pending Feasibility Check	PBS is currently checking feasibility.	Benefit not visible since most of the maintenance will now be classed as corrective rather than preventive. -Technical feasibility not yet studied. Waste streams (liquid, gas, solid) not defined, nor their treatment. ESPN inspections to be defined - base preventive ORE uncertain.
041	Qualification of valves to a higher dose	https://user.iter.org/?uid=5D5AXC	235.4	Yes	Yes	No	Yes	Pending Integration Decision	Work foreseen but not started by PBS yet	DRM modification needed: Split the approach for valves and actuators Valves => 1,5 MGy - Increasing the level qualification is deemed as achievable.
043	Derogation of lipseal inspection	https://user.iter.org/?uid=5D5F77	EQ-15 : 147.6	Yes	Yes	No	NO	Pending Integration Decision	Require Senior Management decision	Taskforce to be set up by RBSE. DRM related to DRM 024
044	Derogation of IBED and CCWS inspection	https://user.iter.org/?uid=5D5GB5	145.1	Yes	Yes	No	No	Pending Feasibility Check	PBS is currently checking feasibility.	Risk analyses and instruction manuals are not yet produced, so not enough material to optimise the inspection schedule.
045	IBED and CCWS remote inspection	https://user.iter.org/?uid=5DMJZ7	145.1	Yes	Yes	No	No	Pending Feasibility Check	PBS is currently checking feasibility.	Risk analyses and instruction manuals are not yet produced, so not enough material to optimise the inspection schedule.

Updated – DRMs over 100 mSv reduction

DRM Selection for N=3

- Objective of N=3 ORE estimate is to support RPrS update and **design and operation**.
- Based upon the integration of DRMs for which IO have a high degree of confidence that they can be implemented.
- DRM selection for N=3 performed by RBSE based on feedback from PBS during workshops, and engineering judgement.
- Selection is independent of the IO Integration Status (see above).
 - If a DRM is not considered for N=3, this does not mean the DRM should be dropped by IO.
 - No for N=3 → lower degree of confidence in successful implementation based on information available

DRMs – IO Integration Status

- Definitions:
 - Validated
 - DRM integrated in ITER Design Baseline
 - Integration on-going
 - Being studied by the PBS for integrating the DRM in the design
 - Pending integration decision
 - Require Senior Management decision
 - Work foreseen but not started by the PBS yet
 - Pending Feasibility Check
 - Either list of actions from the tracker
 - Or PBS is currently checking the feasibility
 - Rejected
 - Workshop - PBS states that not feasible

N=2 DRM Examples

Generic DRM

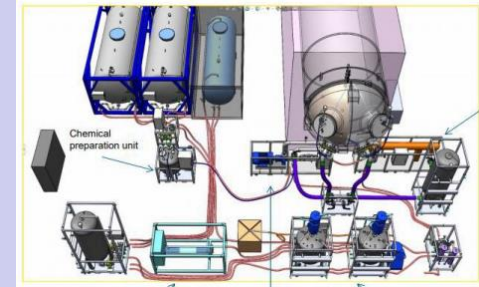
- Coordinated work schedule
- Checklist for Tools
- Rehearsal of tasks
- Operator training

Elimination/Reduction of PIC inspections

(Maintenance Optimisation)

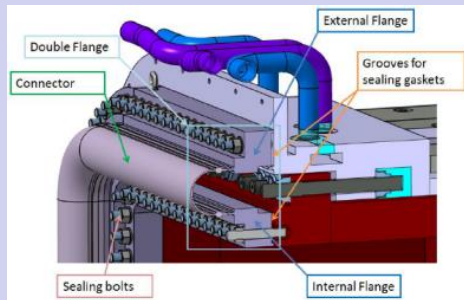
- ➔ Sampling approach
- ➔ Reduced frequency
- ➔ Remote inspection

Chemical cleaning IBED

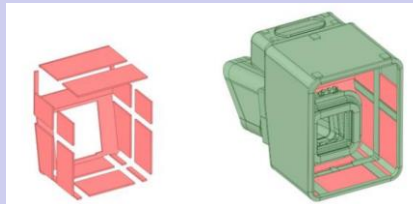


Step N=2 DRMs

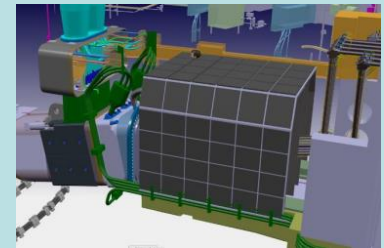
Replace Lipseal with MGSF (Design Change)



Permanent Shielding in the Port Duct (Shielding)



Implementation of shielding cabin and curtains (Shielding)



ACP BACK UP

Review and Update of the IBED PHTS – Phase 1

Update of material properties

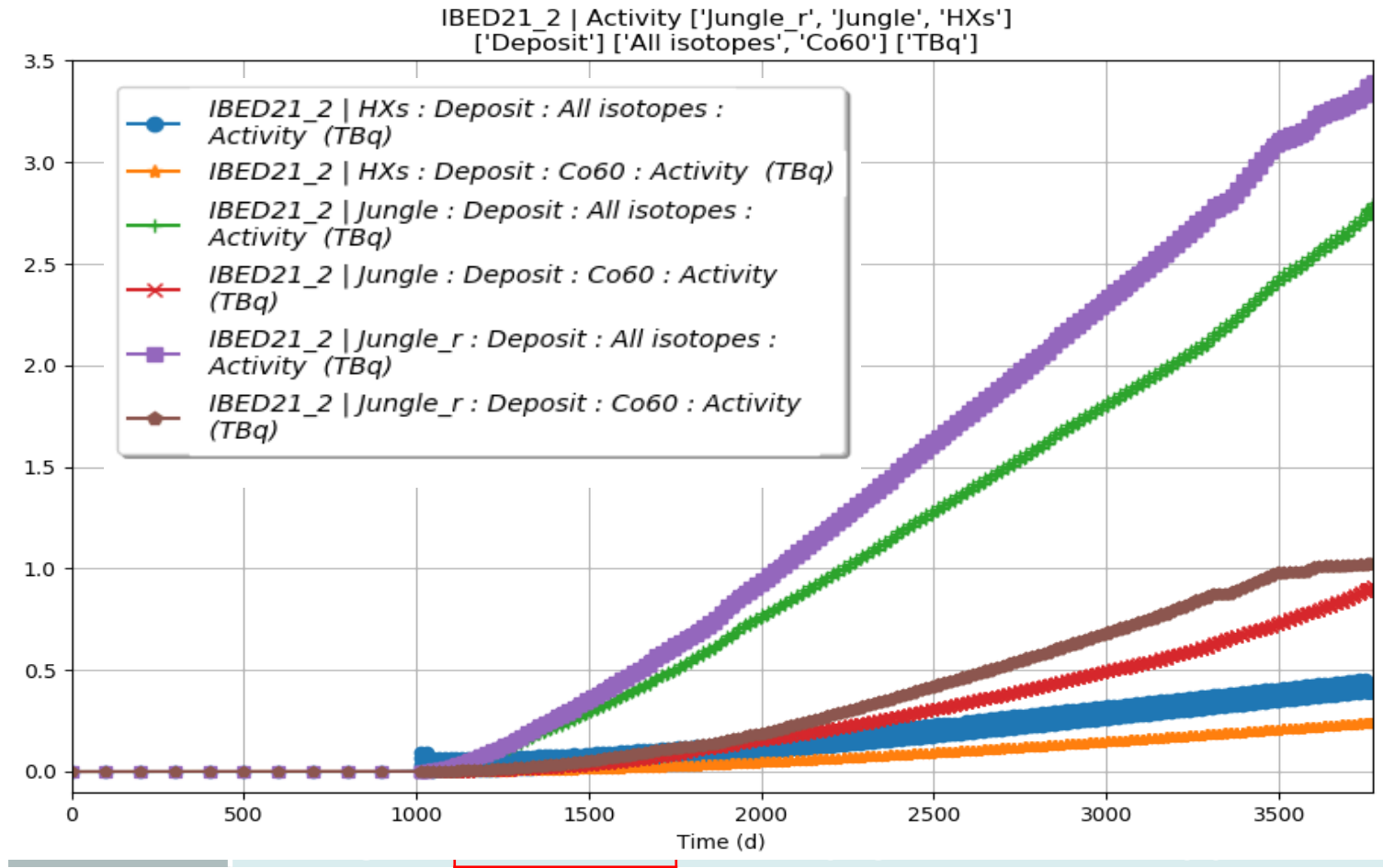
	Baseline 2020	IBED22	Comment
Inner Oxide			
Initial Thickness [μm]	0.1	0.01	Low value set to simulate PHTS conditioning
Specific mass [g/cm ³]	4	5.0	FeCr ₂ O ₄ without porosity
Roughness [μm]	6.3	12	Max roughness value for TCWS piping [3]
Deposit			
Initial Thickness [μm]	3.15	0.05	Low value set to simulate PHTS conditioning
Specific mass [g/cm ³]	4	5.2	FeFe ₂ O ₄ without porosity
Roughness [μm]	6.3	12	Max roughness value for TCWS piping [3]
Tortuosity	1.4	1.6	Layers of spherical particles

+ Other parameters

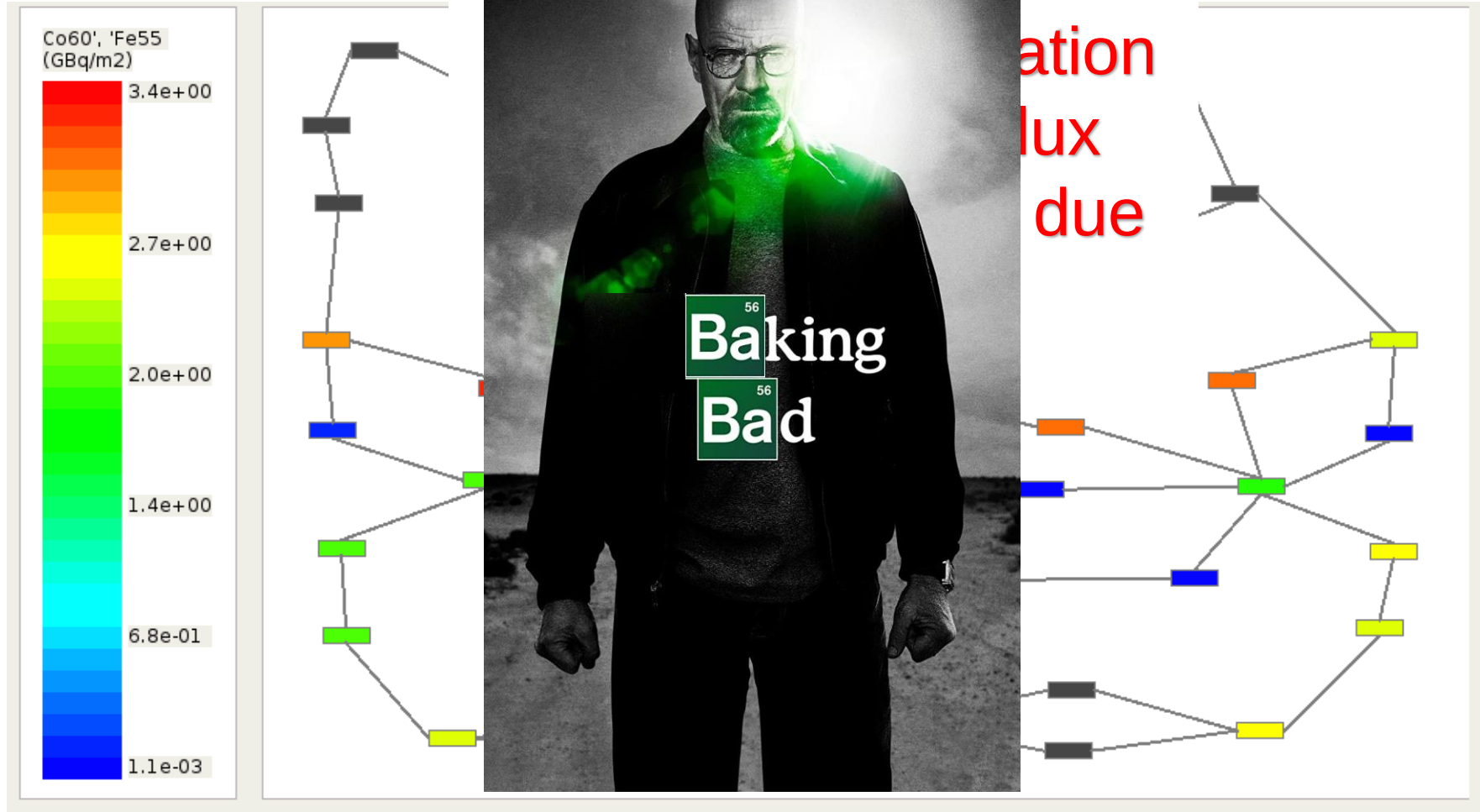
DIV & FW-INOX	Baseline 2020	IBED22	Comment
Inner Oxide			
Initial Thickness [μm]	0.1	0.01	Low value set to simulate PHTS conditioning
Specific mass [g/cm ³]	4	5.0	FeCr ₂ O ₄ without porosity
Roughness [μm]	6.3	6.3	Max roughness value for TCWS piping [3]
Deposit			
Initial Thickness [μm]	3.15	0.05	Low value set to simulate PHTS conditioning
Specific mass [g/cm ³]	4	5.2	FeFe ₂ O ₄ without porosity
Roughness [μm]	6.3	6.3	Max roughness value for TCWS piping [3]
Tortuosity	1.4	1.6	Layers of spherical particles

DIV - CuCrZe	Baseline 2020	2022	Comment
Inner Oxide			
Initial Thickness [μm]	0.1	0.01	Low value set to simulate PHTS conditioning
Specific mass [g/cm ³]	4	5.4	CuCr₂O₄ without porosity
Roughness [μm]	6.3	1.6	Updated data from PBS 17
Deposit			
Initial Thickness [μm]	3.15	0.05	Low value set to simulate PHTS conditioning
Specific mass [g/cm ³]	4	7	(Cu, Fe₃O₄) without porosity
Roughness [μm]	6.3	1.6	Data from PBS 17
Tortuosity	1.4	1.6	Layers of spherical particles

Out of Flux Regions Comparison



IBED 21 – Focus on Baking Consequences



Parameters	ITER	EPR
Pipe length (m)	>25km	
Wetted surface (m2)	~26 000 m2 (~40% HX, 30% In flux)	46 300 m2 (ordre de grandeur)
Volume of water (m3)	~376 m3 (450)	335.9 m3
Water inventory (GBq/m3)	8 GBq/m3	
Water temperature (Degree C)	70C – 240°C	20-350°C
Water flow rate (m/s)	4 – 9 m/s 516 – 4920 kg/s	51-72 m3/h
Wetted surface (m2) / neutrons flux (n.cm-2.s-1)	~7.7k m2 (in-flux regions)	10000 m2 (ordre de grandeur)
Main materials	304L, 316L, Cu, CuZrCr	Austenitic stainless steels Martensitic stainless steels Alloy 690 for steam generator tubes Stellites
roughness	6.3 mm (in specification) - 13 µm CuCrZr may be 3 mm from manufacturing feedback	Stainless steels :1.6 µm Alloy 690:0.1 µm Stellites:1.6 µm
Corrosion rate	SS: 3e-6 g/s/m2 Cu: 4.4E-6 g/s/m2 CuCrZr: 4.4E-6 g/s/m2	Austenitic stainless steels 2 mg/dm ² /mois, moins de 0,3 µm/an de perte d'épaisseur Martensitic stainless steels : 1 à 5 mg/dm ² /mois (soit 0,2 à 0,8 µm/an) Alloy 690: perte d'épaisseur est de l'ordre de 5 mg/dm ² , soit moins d'1 µm/an Stellites: 105 mg/dm ² /mois, soit 15 µm/an
Number of valves	>3000 , 1000 actuated valves	
Quantity of ACP in the cooling system (Kg)	~45 kg With the total radioactivity ~2.5E+14 Bq	
Quantity of ACP removed by outage (Kg)	~32kg in the representative CVCS	
Dose rate around cooling lines	0,3 to 2 mSv/h (Co60)	
Collective dose per maintenance period (men.mSv)	2020 (3VZT2E) : 2500 man.mSv / LTM (Long Term Maintenance=8 months every 16 months)	Target radiation dose for radiation workers in the EPR= 0.35 Man.Sv/yr

	ACP 2019 – EPNS (CEA experts not involved)		ACP2022 – RBSE (CEA experts involved)	
Code	OSCAR V1.3		OSCAR V1.4	
Geometry	IBED PHTS FWB DIV		Same	
Roughness	6.3 micron (from FWB spec. extended to all)		12 micron (from circuit spec.)	
Initial deposit	3.15 micron (= roughness/2 based on EDF REP feedback but with roughness of 1.6- 2)		0.05 micron (correspond to “fresh”circuit , from CEA experts)	
Conditioning of circuit	no		1000 days of PFPO	
Operational scenario	18 days sessions with (XNXW3N) : • 16 plasma pulses 400 s/ day during 15 days • 3 days of baking (modelled with plasma equivalent/day)		18 days sessions with (RWBRH3): • 9000 s plasma/day during 15 days • 3 days of baking (modelled with plasma equivalent/session)	

	ACP 2019 – EPNS (CEA experts not involved)		ACP2022 – RBSE (CEA experts involved)
Deposit density	4 g/cm3 (wrong input)		5,2 g/cm3
porosity	0.5		0.5



Parameter that will increase ACP



Parameter that will decrease ACP

Oscar changes (to be complemented after meeting with CEA 29/11/2022)

	OSCAR V1.3	OSCAR V1.4

	ACP 2019 – EPNS (CEA experts not involved)		ACP2022 – RBSE (CEA experts involved)
Total activity EOL Out of flux region	2,6 TBq		12 TBq
ACP mass	Total 39,5 kg (44 kg in STTF) Recalculated in 2022 with 2019 inputs and Oscar V1.3: Total 190 kg • 140 kg out of flux • 50 kg in flux		Total 85 kg • 30 kg out of flux • 55 kg in flux

On going: checking possibility to perform calculation with OSCAR V1.3 using all the 2022 inputs (internal use only**)**

Area	comment	ALARA workshops	Final Workshops (slides)
UP16	ECH port (PBS52)	ITER_D_YSGMCH	ITER_D_6AQZXN (4/11/22)
UP01	Diag port (PBS55)	ITER_D_3YL6GP	ITER_D_6AQZXN (4/11/22)
EQ08	Diags ports (PBS55) with vacuum extensions	ITER_D_2YAQGM	ITER_D_697H3U (27/10/22)
EQ10	Diags ports (PBS55)	ITER_D_2Y75AU	
EQ15	ICH port (PBS51)	ITER_D_5D5BAW	
EQ16	TBM port (PBS56)	ITER_D_4YMHQ8	ITER_D_6UALSF (14/11/22)
LP02	RH port at B1	ITER_D_5K9JLQ	ITER_D_6AW9HG (8/11/22)
LP04	Cryo Pumps (PBS31)	ITER_D_2X59UA	
LP11	IVVS port (PBS57)	ITER_D_5PRTFM	
NB Cell (L1/L2)	NB systems (PBS53)	ITER_D_3AREPV	ITER_D_69F4TS (2/11/22)
UPPC (L3)	TCWS	ITER_D_2EWYNV	ITER_D_6AWJ87 (10/11/22)
LPC (B2)		ITER_D_57JD99	
DTR (B2)		ITER_D_5JXVZT	

KEY documents

WP	idm
WP3 – integrated maintenance	ITER_D_2LQL2J (Year 1) ITER_D_3AMQGL (Year 2) TBD (year 3) > 5U5ZK4
WP4 – Dose rate maps	ITER_D_3GS3KM (Year 1) ITER_D_3KY9AB (Year 2) TBD (year 3) > 68VR7F
WP5 – Contamination studies	ITER_D_YNCAGV (Year 1) ITER_D_X9XWTZ (Year 2) ITER_D_X9XZBH (Year 2 – HCC)
WP6 – Maintenance standardization	See specific slides
WP7 – Human & Organization Factor	ITER_D_2LPF4Y (Year 1) ITER_D_4XXYTC (Year 2)
WP8 – Health & Safety	ITER_D_YPD6QL (Year 1) ITER_D_5CFDC4 (Year 2)
WP9 – ALARA	ITER_D_YNCBSS (Year 1) ITER_D_57JTFS (Year 2) TBD (year 3) > 6976LV

- In the frame of NIE, a WP10 was created to prepare radiation safety chapters for RPrS based on current set of input.

WP	idm
WP10 – Radiation Safety files	Mode 0 (Fr): ITER_D_7P75AD Mode 1 (Fr): ITER_D_7U8K3T Mode 2 (Fr): ITER_D_7P7K9C First Plasma (Fr): ITER_D_7Q9X6Y

WP6 – Maintenance standardization

JACOBS NIE WP6:

WP6 Workshop Presentations:

- [ITER D 3QAYZC - NIE Contract WP6 Workshop Presentation \(Year 1\)](#)
- [ITER D 3AJZYA - NIE WP6 YEAR 2 WORKSHOP PRESENTATION \(Year 2 Launch\)](#)
- Feasibility Studies (Year 1):
- [ITER D YBVR4Z - WP6 – Feasibility Report – Contamination Control during the disconnection of IBED Pipes \(Linked to IA10 2ZAMFT\)](#)
- [ITER D 3P8JDA - WP6 – Feasibility Report – Port Cell Sampling Strategy during Maintenance Operations](#)
- [ITER D 3ECRQD - WP6 – Feasibility Report – Soft Material Protection Tent in Port Cell](#)
- [ITER D 3J68JG - WP6 – Feasibility Report – Standard Approach for VV 1st Confinement Barrier Disconnection](#)
- [ITER D 3ECL4C - WP6 – Feasibility Report – Use of Airlocks and Confinement Tents](#)
- [ITER D 3K5DGS - WP6 – Feasibility Report - Use of Cask Docking Flange for the Sealing Flange removal/installation – Welded Lipseal Sealing Flange](#)

P1 Topic Studies (Year 1):

- [ITER D 3SHJB4 - P1 Item - Concept Design Study - Port Plug Tilting Mechanism](#)
- [ITER D 3SK2U2 - P1 Item - Concept Design Study - Sealing Flange Removal Metallic Gasket Option](#)

P2 Topic Studies (Year 2):

Human Access Airlock

- [ITER D 4MF3NR - Human Access Airlock Final Report](#)
- [ITER D 47DULZ - Human Access Airlock Workshop Presentation](#)
- [ITER D 4KGSYQ - Human Access Airlock PPE Clarification](#)
- Temporary Shielding Port Plug:
 - [ITER D 57N4EL - Comparison of Dummy PP and PP for Shielding effect](#)
 - [ITER D 5F8H7F - PLUG Temporary Shielding Final Report](#)
 - [ITER D 55TKGG - Temporary Shielding Workshop Presentation](#)
- Metallic Gasket Sealing Flange Handling Equipment:
 - [ITER D 596R48 - Sealing FLange Maintenance Equipment Final Report](#)
 - [ITER D 52NBDM - Sealing Flange Workshop Presentation](#)
- Maintenance Cabin:
 - [ITER D 5H9BSE - Maintenance Cabin Workshop Presentation](#)
 - [ITER D 5GWKR2 - Maintenance Cabin Airlock Optioneering](#)
 - [ITER D 58QYYL - Maintenance Cabin HAZOP-Study](#)
 - [ITER D 5GF768 - Maintenance Cabin Contamination Risk](#)
 - [ITER D 5JXTKA - Maintenance Cabin Final Report](#)

Port Cell Maintenance Process Strategy:

• [ITER D 5MHK8V - Draft Port Cell Maintenance Process Strategy](#)

RACE UKAEA Mock-up Trials:

RACE IA10 – Quick Connector Trials for Cooling Water IBED Pipes (Trials planned Q4 2021)

- [ITER D 47VZ4Y - Final Design Review Presentation](#)
- [ITER D 2ZAMFT - IA10 Contamination Control Study](#)

RACE IA11 – Port Plug Bolting Trials – Insertion and removal of M52 bolts using KUKA KR150 with End Effector (Trials planned Q4 2021)

- [ITER D 47TNGE - IRTF IA11 Final Design Report - D6](#)

RACE IA14 – Port Plug Bolt Tensioning Trials – RH Compatible Nord-Lock Superbolt Tensioning Tool (Trials planned Q2 2022)

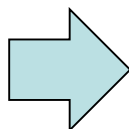
- [ITER D 5PTWXV - 20210804-Final Design Review-IA14](#)

CEA Cask Docking Flange Study:

- [ITER D 456X7G - D4 - SSA85 - Summary Report](#)
- [ITER D 3AUDNH - SSA-85 CEA progress meeting Hold Point 2](#)

Telerobot Cask Docking Flange Study:

- [ITER D 4KA3PR - D3 - Cask Docking Flange Concept Proposal and Main Interfaces Details](#)
- [ITER D 4JU82Y - D6 CEA Sealing Technology Laboratory- Reports](#)



[ITER_D_5MHK8V - Proposal for a new Port Cell Maintenance Strategy](#)