Official IEC 61508 Hazard Identification for the ion source and LEBT test stand.

Meeting Date

2018-01-30

Location

Meeting Room Sofiero, ESS offices Tunavagen, Lund

Chairman
Stuart Birch

Secretary
Birch, Stuart / Denis Paulic

Attendees
Ida Bergstrom (IB)
Edgar Sargsysan (ES)
Michael Plagge (MP)
Morteza Mansouri (MM)
Oystein Middtun (OM)
Denis Paulic (DP)
Fredrik Jorud (FJ)
Freddrik Tidholm (FT)
Stuart Birch (SLB)

Absentees
Thomas Hansson

Review

1. Introduction

SLB opened the meeting with brief description how the ion source test stand became part of the ICS protection teams scope and described that part of the IEC61508 lifecycle is to have an official meeting with stakeholders of the system. SLB also pointed out that currently the radiation hazards were not within the scope of the PSS0 system design. SLB stated that this may change and an extra meeting would be held at a later date.

SLB stated that the required outcome of the meeting was to:

- Broad agreement between ICS, AD and ES&H that all hazards have been identified for the PSS0 controlled areas.
- The meeting will be recorded as a set of minutes and added to CHESS
- All participants in this meeting will be asked to approve. Thus, confirming that all hazards have been identified.
- If subsequently more hazards it will be added as an addendum to the documentation

After the minutes have been approved by the stakeholders, any required document changes will be carried out and shall go through the CHESS check and approval process to ensure traceability throughout the process. The Hazard identification and risk assessment document can be completed and shall include all new hazard information from this meeting.

SLB gave a presentation detailing the following

- An overview of the ion source and LEBT test stand
- The PSS0 controlled area
- The hazard safety review (November 2017)
- The hazard register. (DP) gave detailed description of the hazard register process. and how the data is to be interpreted
- Other hazards which are mitigated with either procedural processes or mechanical barriers (terminal covers etc.)
- Risk Matrix SLB and DP described the matrix used in the hazard process. (DP pointed out that the matrix will probably be updated at some point in the near future.

2. Questions, Minutes and List of Actions

Question (FJ) If there was a water leak into the tunnel what would be the effect on the test stand and the PSS0?

Answers (OM)You would require the water level to be around 1 metre before the HV would be effected.

(SLB) a 600 metre tunnel would need 3600 cubic metres of water (3.6 million litres) this is highly improbable.

(FJ) So entering this area is not advisable when water in tunnel?

(SLB) Yes

Question (FJ) Fire question If there is a fire in the PSS0 controlled area how does ESS/fire brigade ensure that the HV power is de-energised?

Answers (MM)There is an E Stop on the outside of the HV safety fence. This will de-energise the HV power supply and operate the grounding relay.

(FJ) There is also the main circuit breaker at the distribution board in the front end building

(SLB) this would be the best solution as it would remove all power from the controlled area.

Question (MP) Is there an automatic power de- energise interlock if there is a fire?

Answers (FJ) Currently not at the moment and it has never been discussed.

Question (MP) Will the tunnel lights be switched off if the main distribution board is de-energised?

Answers (MM & SLB) No the tunnel lights are on a different board from elsewhere in the facility (G02 klystron Gallery).

Question (FJ) Is the HV relay designed and manufactured to any standards?

Answer (SLB) The relay is built to American standards IEEE C37. 100. (standard for power switchgear) and tested to IEEE4. (Techniques for high voltage testing). The ground rod is manufactured to **IEC 60855**-1:2009 Standard | Live working - Insulating foam-filled tubes and solid rods.

Question (FJ) Do we have a risk assessment from any other facilities so ESS can see whether the system is similar to others?

Answers (MM) No, but we may have one from CERN, (OM) used to work at Linac 4 he is probably best to see if the systems are similar, and Richard Scrivens (Linac 4) will be on the review committee.

Review

Question (MP)	Is the HV "signal" lights effected by the turn off of mains power to the HV power supply
Answer (MM)	No, the HV "signal lights are driven from the PSS0 plc system so will not be effected.
Question (ES)	Will the PSS team be required to carry out the formalised search before switch on?
Answer (MM)	It will be AD that will carry out the searches. All personnel will be fully trained and must be authorised to enter the PSS0 controlled area.
Question (FJ)	Can you put anything in a way of grounding relay to prevent form putting it in place?
Answer (SLB)	No. the ground relay will be within a polycarbonate cover.
Question (FJ)	Maintenance of PSS, how do we make sure HV cannot be started?
Answer (SLB)	Main function is de energizing the contactors. As soon as somebody enters, they will open and make sure the HV won't/cannot be started.
Question (FJ)	What if the contacts are welded and can that be initiating event?
Answer (DP)	No need to include these as an initiating event. These failures are included into PSS0 analysis. Dangerous failures.
Question (FJ)	Abnormal humidity conditions… Can we electrify the cage?
Answer (MM)	The cage is fully grounded.
Answer (ES)	The ISrc and LEBT test stand is designed for 70% humidity.
Answer (MM)	The cage was tested with 50-60% humidity.
Answer (OM)	You will see some flashes, electrical noise. They haven't experienced any humidity issues. But no tests been done on 90%. There are temperature and humidity sensor on the cage.
Answer (ES)	Currently the humidity in the G01 tunnel is 45-55%
Statement (FJ)	In order to handle emergency procedure… Emergency power insulation and grounding plan (ESS-0042915) – Updates needed to update the document. Can you please check it?
Answer (SLB)	We'll have a look. Send an email.
Question (FJ)	Hydrogen gas bottle, is there an ATEX report? It will need to be completed and approved before operation of the ISrc and LEBT test stand.
Answer (SLB)	Not a scope of this system. It is mentioned in our documents.
Answer (ES)	This is not completed yet. We need help from ES&H to provide ATEX experience/consultant to help with this study..
Question (FJ)	Why are there no radiation hazards mentioned in the Hazard identification?
Answer (SLB)	We are building a high voltage test stand which, currently does not have radiation in the scope as agreed in mid-2017.
Answer (ES)	Safety cage design document should cover the radiation risk assessment and analysis.

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Statement (IB) We will have safety review for the test stand and it's important to know who did and where is the risk assessment for ionizing radiation.

It was broadly agreed in the meeting that the hazard identification for the PSS0 HV safety system was complete and covers all hazards and initiating events for the PSS0 high voltage safety system.

Meeting Close 12:45

Presentation SLB

Review

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PSS0 Scope

- Scope of PSS0 was agreed in mid 2017 (minutes of meetings: ESS-0115443, Minutes-2017-04-20.pdf. and 2017-07-05: ESS-0121953

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Introduction

Outcome from this meeting:

- Broad agreement between ICS, AD and ES&H that all hazards have been identified for the PSS0 controlled area.
- The meeting will be recorded as a set of minutes and added to CHESS
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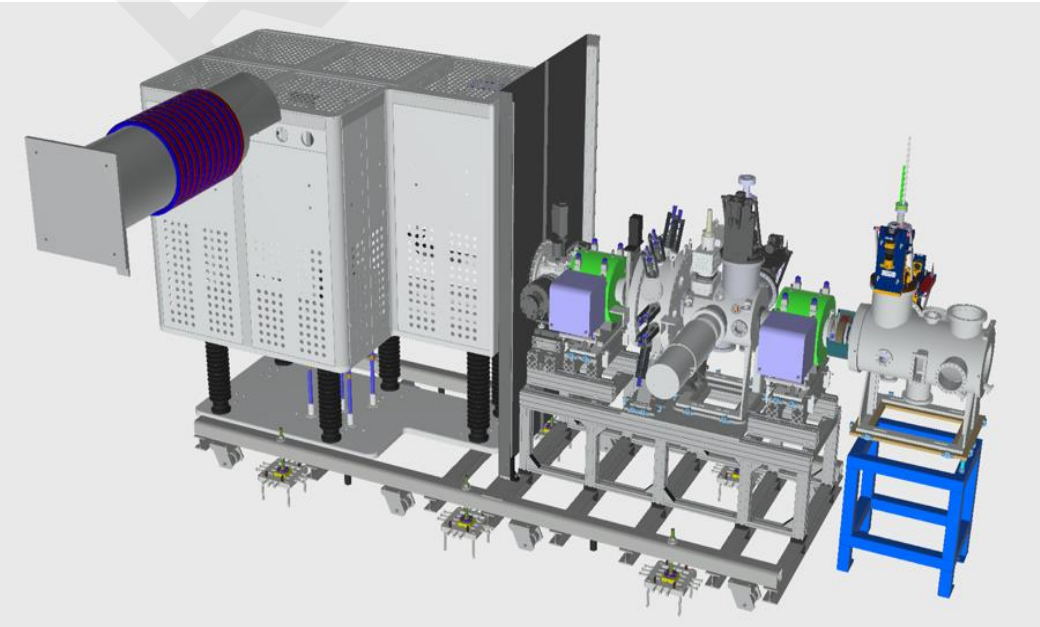
Isrc & LEBT



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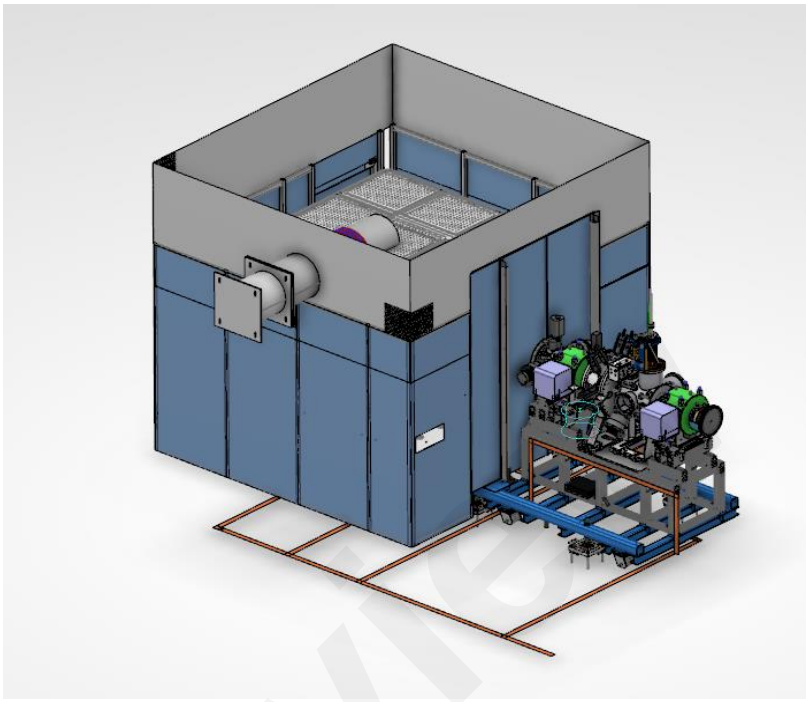
ISrc & LEBT



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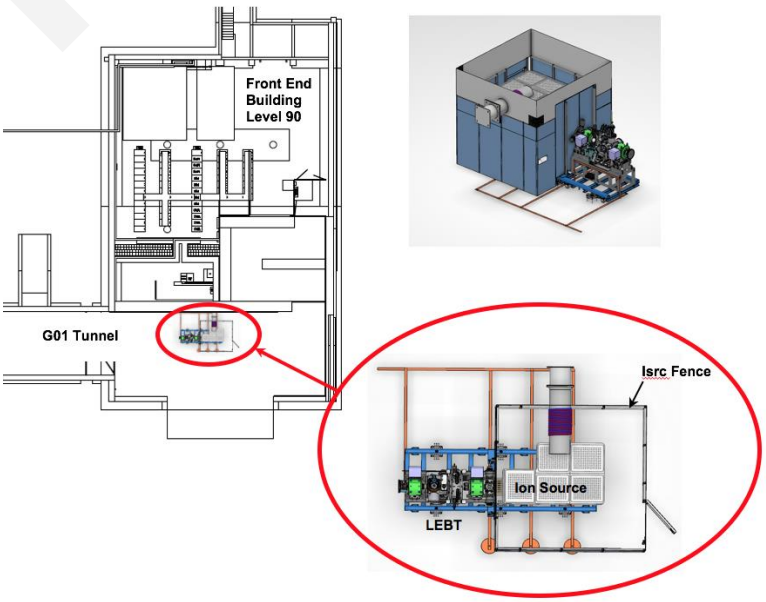
Isrc & LEBT Test Stand Position



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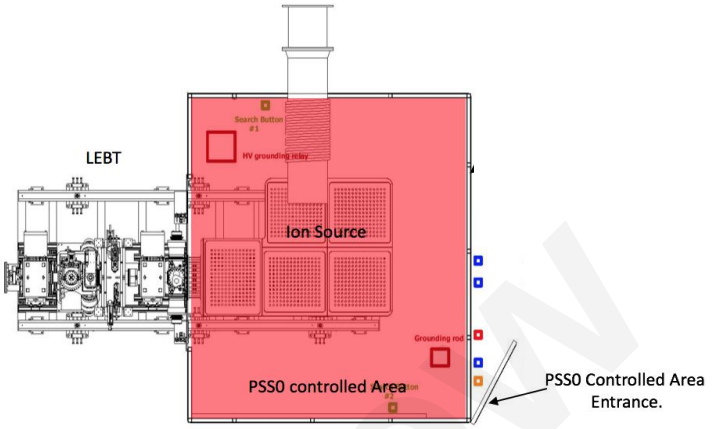
PSS Controlled Area.



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Hazard Identification

The HAZID took the form of a meeting involving various disciplines and roles within ESS and the Accelerator project. The meeting considered each of the controlled areas within the accelerator, in which the PSS will provide access control and safety interlocks. This meeting covers only the PSS0 controlled area.

Attendance
The following ESS personnel attended the meetings:

- Stuart Birch, Senior Engineer Personnel Safety Systems
- Denis Paulic, Deputy Group Leader Protection Systems
- Morteza Mansouri, Engineer for Safety Critical Systems, Personnel Safety Systems
- Oystein Midttun, In-Kind Collaborator
- Edgar Sargsyan, Section Leader Front End & Magnets

Safety review November 2017
https://confluence.esss.lu.se/display/LG/2017-11-01+Ion+Source+safety+cage+and+PSS0+design+review

For PSS0, the following have been considered:

- The High Voltage hazard, <100kV
- The degree of potential harm to people, Death by electrocution
- Who could be harmed, Personnel who enter whilst High voltage extraction system is energised
- The frequency of opportunity for harm, Isrc & LEBT test stand 248 days, entry into controlled area 2 times per day, when HV de-energised, and fence gate opened, constant access.

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PSS0 Hazard Register

Hazard ID IE number	Hazard	Initiating Event (IE)	Consequences	Likelihood (Frequency/ Year)	Barriers and procedures	PSS safety function required Yes/No	Protection and Mitigation	Human Actions	Risk Reduction (with PSS0 functions in place and working)	Recommendations and comments	Screening (IN/OUT)
PSS_Hazard_003 IE_01	Electrical Hazard (High Voltage)	A person enters into PSS0 controlled area (Fenced area) whilst the HV is ON.	Hazardous	1.0	1. PSS0 key exchange - mechanical sequence	Yes	1. Prevent access by locking the access gate when HV PS is on 2. Alert personnel outside the fenced area - HV ON light + Blue (Beam ON light) 3. Access gate position monitoring Action: Upon detection of door opening immediately switch-off the mains power to the following systems Ion Source HV PS (Extraction System).	Entry procedure to fenced area (PSS0 controlled area). Exit from PSS0 controlled area.	Tolerable		IN
PSS_Hazard_003 IE_02	Electrical Hazard (High Voltage)	A person is in PSS0 controlled area when HV unexpectedly starts.	Hazardous	52.0 (1/week)	1. PSS0 key exchange - mechanical sequence 2. Formalised search	Yes	1. Monitoring the position of PSS0 Accesss key Action: Upon removing the PSS0 Access key from its position, switch-off the mains power to the Ion Source HV PS Extraction System 2. Position monitoring of safety key and search breaking Action: Reading the position of the safety key when entering with key (safety token) – preventing operator from issuing the HV permit when people are inside. 3. Search breaking upon opening the access gate Action: Upon detecting the opening of access gate break the search, which will then remove the permit to switch on HV PS when people are inside.	Formalised search Entry into controlled area	Tolerable	The high voltage safety rod - when in position on the HV platform, the HV will be dumped down to ground. HV ON Warning signalisation - not valid for this IE. A worker inside the fenced area will not know if the HV is ON. (additional measure is putting the rod in place) There is no E-stop button inside the fenced area.	IN

Other Src & LEBT test stand hazards

Hazards on the ion source and LEBT test stand ESS-0118213

	Hazard	Mitigation
Solenoids and Steerers	Low voltage	Terminal covers
Electron repellers	High Voltage 3.5kV	The two repeller electrodes use standard insulated BNC 5HV connectors. (no open connections)
Chopper	High Voltage 10kV	The chopper uses standard insulated BNC 5HV connectors. (no Open connections)
Faraday cup guard ring	High voltage 1.5kV	The Faraday cup uses standard insulated BNC 5HV connectors. (no Open connections)
Emittance Measurement unit	High Voltage Guard rings 1.5kV and bias plates up to 4kV	The EMU uses standard insulated BNC 5HV connectors. (no Open connections)

Explosive hazard. There is a risk involved with the presence of hydrogen gas. Avoiding accumulation of hydrogen in case of a leak mitigates this risk. The 5-liter hydrogen bottle sits inside the high voltage platform, and the holes in the roof allow the hydrogen to escape. The high voltage protection cage has 1 m above the lead shielding where it is not completely closed, and this allows the hydrogen to propagate into the tunnel. The volume of the tunnel is large enough to dilute the hydrogen below the explosive limit of hydrogen in air.

Risk Assessments

As described in the Concept Document (ESS-0048724) the following Risk matrix's where used to carry out unmitigated risk assessments:

			Consequence				
			Negligible	Minor	Major	Hazardous	Catastrophic
Likelihood			A	B	C	D	E
Frequent	1	$>10^{-2}$	1A	1B	1C	1D	1E
Occasional	2	$>10^{-3} \leq 10^{-2}$	2A	2B	2C	2D	2E
Remote	3	$>10^{-4} \leq 10^{-3}$	3A	3B	3C	3D	3E
Improbable	4	$>10^{-5} \leq 10^{-4}$	4A	4B	4C	4D	4E
Highly Improbable	5	$<10^{-5}$	5A	5B	5C	5D	5E

Unacceptable	Risk level is unacceptable and risk reduction shall be carried out. Regulatory requirements on acceptable risk level are not met.
Tolerable	Regulatory requirements on acceptable risk level are met. Risk level is tolerable; however, evaluation of the possibility to further reduce risk is recommended.
Acceptable	Risk reduction is not required.

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Questions

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Extra slides not used

- Without the HV grounding relay; the capacitors and cable will discharge in 250 ms through the 10 MOhm resistors.
- - With the HV grounding relay; the capacitors and cable will discharge in 200 us through the HV grounding relay.
- This means even if the grounding relay fails (not the contactors to the incoming mains power of HVPS), the residual energy of capacitors will be dissipated through the resistors within 250 ms. (I attached the drawing for the output stage of HVPS).
-
- 2- The grounding rod (in addition to the grounding relay) is being used as part of the requirements in SS-EN 50110-1:2013 standard, where we need to *Carry out earthing and short-circuiting*.
- The grounding rod is used as an additional layer for grounding the HVPS, and if we don't install the grounding rod, our system will not be really affected (the grounding relay serves this purpose already).
- 3- In case we need to keep IE03, then the access frequency to the PSS0 controlled area in IE03 will be 2x248. (248 working days per year).
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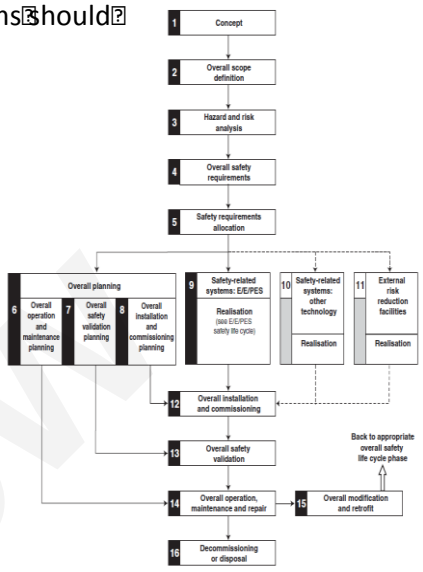
PSS Strategy (IEC61508)

In line with many similar accelerator based facilities around the world, Is was decided in 2012 the the ESS personnel safety systems should be designed in accordance with IEC61508:2010.

The IEC61508 safety life cycle has 16 phases which roughly can be divided into three groups as follows:

Phases 1-5 address analysis
Phases 6-13 address realisation
Phases 14-16 address operation.



IEC61508 lifecycle

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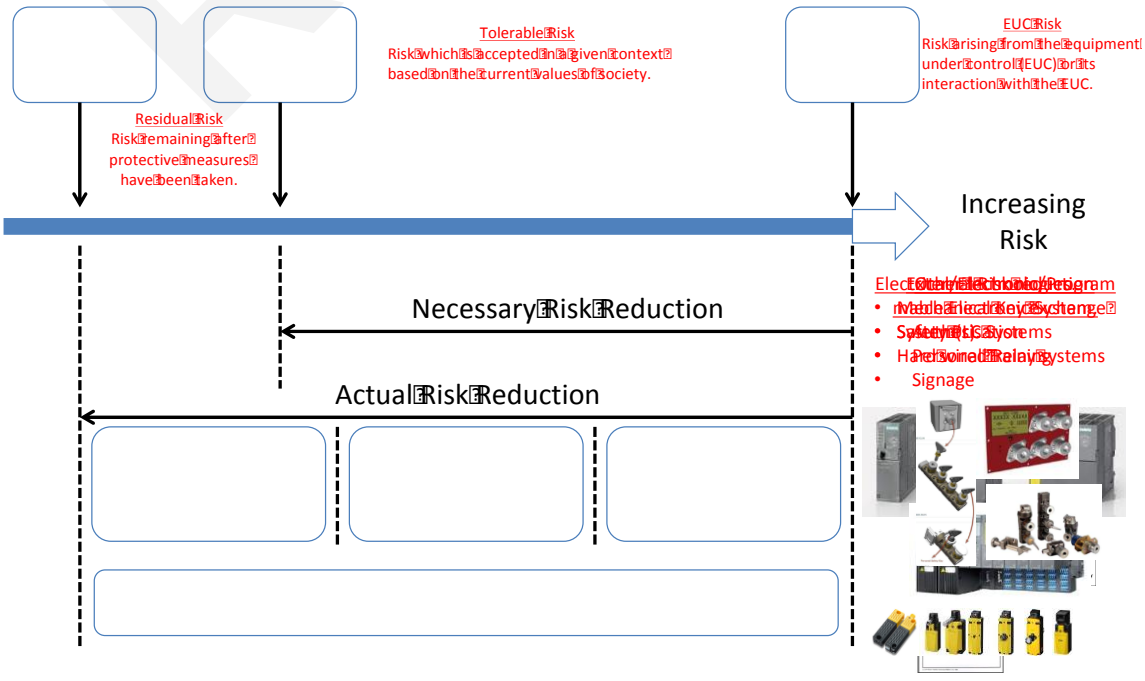
PSS Strategy (IEC61508) Risk



PSS Strategy Summary

The ESS Personnel safety system strategy will be:

- Safety Related System(s).
- Designed, manufactured, commissioned and validated to IEC61508 using proven technology.
- A two train system
- A fail safe system
- Single failure
- Common Cause Failure
- Redundancy
- Diversity
- Separation

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Review