FLUORO ACTION LEVELS

TJC Reviewable Sentinel Event; Radiation overdose involving prolonged fluoroscopy with a cumulative dose of more than 15 Gy (1,500 rads) to a single field. To ensure compliance with this TJC standard the following fluoro action levels are proposed.

1. The imaging **Procedure Action Level** measured in minutes of fluoroscopic "ON" time, dose area product (DAP), commonly presented in units of cGy•cm^2 or air kerma (Gy) is intended to warn the physician that the patient radiation dose levels may be at 50 percent of values expected to produce a visible skin effect. At this point, the operator should consider and utilize techniques to reduce the single field skin dose such as changing beam orientation and further reducing any unneeded overall exposure.

2. The patient **Follow up Action Level** sets a threshold for the potential to create a radiation dose to the skin that could be visible. The threshold represents a skin dose of approximately half of the Sentinel Event limit. These patients should be contacted to determine if they have experienced any unusual or unexpected reddening or other effect to their skin. If the patient indicates an unusual reaction, they should be scheduled to return for follow-up and any recommended medical treatment, if required.

3. The **Reporting Action Level** sets a level for which significant radiation damage to the skin may be likely and requires reporting to the Radiation Safety Officer and the Patient Safety Officer. An occurrence report will be entered as a Patient Safety Net report for any fluoroscopy time, air kerma or DAP.

These three action levels are an attempt to approach a generally complex problem in a relatively simple manner. However, certain patient and procedure dependent factors must be considered. For this purpose, **action level modifiers** are introduced. As a guideline, any of up to two modifiers may be applied to reduce the action levels as shown in the following table.

The action level modifiers are listed below, however, the last two apply only to action levels specified in minutes and do not apply for dose area product or air kerma values.

- a patient weighing over 100 kilograms (220 pounds)
- imaging performed with poor geometry where the patient is closer to the x-ray tube than normal
- imaging time concentrated in one orientation, that is, more than half of the fluoroscopic time with the x-ray beam entering the patient at approximately the same location
- the significant use of high output mode (e.g. High Level Mode, High Detail Mode, HLF, Boost)
- significant use of serial image recording during the procedure

FLUORO ACTION LEVELS

Modifier	Procedure Action Level			Follow Up Action Level			Reporting Action Level		
	(mins)	**(cGy ¶ cm^2)**	**(mGy)**	**(mins)**	**(cGy ¶ cm^2)**	**(mGy)**	**(mins)**	**(cGy ¶ cm^2)**	**(mGy)**
None	50	52,500	4,250	100	105,000	8,500	200	210,000	17,000
1	25	26,250	2,125	50	52,500	4,250	100	105,000	8,500
2	13	13,125	1,063	25	26,250	2,125	50	52,500	4,250

- Clinical Examples Are Given on the next Page -

Clinical Examples using Time, DAP and Kerma

Fluoro Case Using Time: Fluoro time is the least accurate measure of skin doses because is does not take into account any of the machine variables like kVp, mA or image intensified size. It also does not account for dose during serial imaging which can be orders of magnitude more the actual fluoro dose. It is for this reason that the two starred modifiers must be considered if time is the only parameter available. Consider a 250-pound patient who must be imaged in the High Level Fluoro (HLF). Two modifiers would apply in this case so the **Procedure Action Level** would be 13 minutes, the **Follow up Action Level** would be 25 minutes and the **Reporting Action Level** 50 minutes**.** If the fluoro time exceeds 25 minutes the physician needs to evaluate how much time has been spent in any one view and consider changing the orientation to reduce skin dose. The normal or low dose modes should also be considered if the image is adequate. Clinical follow-up may be necessary.

Fluoro Case Using Dose-Area-Product (DAP): The DAP is derived by multiplying the dose times the area of the field of view. It takes into account kVp and mA and includes serial imaging. It is a much more accurate prediction of skin doses than time. It can be somewhat misleading if a number of different image intensifier sizes are used. Consider a normal size patient in a procedure where the orientation is relatively fixed for most of the procedure. One modifier would apply in this case so the **Procedure Action Level** would be 26,250 cGy-cm^2, the **Follow up Action Level** would be 52,500 cGy-cm^2 and the **Reporting Action Level** 105,000 cGy-cm^2**.** If the DAP exceeds 105,0500 cGy-cm^2 the physician needs to report the incident to the Radiation Safety Officer and the Patient Safety Officer. An occurrence report will be entered as a Patient Safety Net report noting the DAP..

Fluoro Case Using Kerma: Kerma is a measure of the dose to air at a certain point in space between the image intensifier and the x-ray tube. The values in the table have been calculated to reflect the kerma levels associated with a notable skin dose for an average size patient. Consider a 220 pound patient in a procedure where the geometry is poor and the patient is closer to the x-ray tube than normal. Two modifiers would apply in this case so the **Procedure Action Level** would be 1,063 mGy, the **Follow up Action Level** would be 2,125 mGy and the **Reporting Action Level** 4,250 cGy-cm^2**.** If the Kerma exceeds 2,125 mGy**.** the physician needs to consider changing the orientation to reduce skin dose. A lower dose modes should also be considered if the image is adequate. Clinical follow-up may be necessary.

BASIC ASSUMPTIONS

1. Action levels should be set in relation to the potential for visible effects on the patient's skin that are well under 1500 rad. A 600-rad value has been used.
2. For time limits, it was assumed that it was usual to use different orientations of the x-ray beam and that only 50 percent of the total time would use the same orientation with the x-ray beam entering the patient at approximately the same location [Relative Time at Skin Location (RTSL)].
3. Serial image recording could produce an additional radiation dose equivalent to the fluoroscopic dose [Image Recording Factor (IRF)] and needs to be accounted for when time is used.
4. The image intensifier is at 40 inches (D_{II}).
5. The beam entrance point is at 22 inches (D).
6. The fluoroscopic output is in roentgens per minute at 12 inches in front of the image intensifier entrance surface (R/min).
7. For Air Kerma a correction factor of 0.88 must be include to convert to rads in tissue.
8. A backscatter factor (BSF) of 1.2 is used to include radiation backscatter from the body to the skin.

Dose = Time * R/min * BSF* $[(D_{II} - 12)/D]^2$ * [RTSL] * [IRF]

Dose (rad)	Time (minutes)	R/min	D_{II} (inches)	D (inches)	$(D_{II}-12)/D$	RTSL	IRF
583	100.0	3.0	40.0	22.0	1.27	0.5	2.0
700	120.0	3.0	40.0	22.0	1.27	0.5	2.0

9. Assuming the air kerma dose reference D_{ref} is at 22.5 inches from the tube focal spot and the dose entrance point is at 22 inches (D), dose to a single entrance port would be:

Dose = Air Kerma * BSF * $(D_{ref}/D)^2$ * [RTSL] / 8.8

Dose (rad)	Air Kerma (mGy)	D	D_{ref}	RTSL
606	8,500	22.0	22.5	0.5
713	10,000	22.0	22.5	0.5

10. Assuming the DAP in cGy ◊ cm^2 with a field size of 7.9 x 7.9 inches (20 x 20 cm) at the image intensifier distance (D_{II}) and the entrance point at 22 inches (D), the dose to a single entrance port would be:

Dose = (DAP * BSF* RTSL / $[(D/D_{II})^2$ * (Field Area)]) / 0.88

Dose (rad)	DAP (cGy • cm^2)	D	D_{II}	RTSL	Field Size @ D_{II}
592	105,000	22.0	40.0	0.5	400.0
995	185,860	25.5	45.2	1.0	800.0