Linearity of Low Dispersion Trailed Spectra Processed with the New LWR ITF

Nancy A. Oliversen

I. Introduction

On November 24-27, 1983 the observations for a new LWR ITF were obtained. Standard star spectra, processed with this new ITF, have been analyzed to study the reproducibility and linearity errors of non-optimum exposures. The observation and analysis techniques are briefly summarized in section II. The linearity errors of spectra obtained in September 1983 are discussed in section III. Sample linearity errors for spectra with high backgrounds is shown in section IV. Finally, linearity errors for spectra obtained in November 1978 is presented in section V.

II. Observation and Data Analysis Technique

The observation and analysis technique used for this study is similar to the method used in Oliversen (1983). The standard star HD 60753 is used for most of this report. The one exception is HD 6300, an early B star, which was conveniently located near to the attitude used for the ITF observations. For comparison, each image has been processed with both the current and new LWR ITF. The linearity errors are determined by ratioing a test image with a standard 100% exposure level image with low background. Each spectral ratio is corrected for camera head amplifier temperature-induced sensitivity changes (Sonneborn and Garhart, 1983) and was then smoothed with a 5 point median filter and with an 11 point boxcar filter. The resultant ratios are then plotted for both the current and new LWR ITF. Finally, each flux ratio was averaged over 100 angstrom bandpasses and are listed in the tables at the end of this report.

III. Linearity Errors for September 1983

The reproducibility of images processed with the current and new LWR ITFs is similar (Figure 1). The flux ratios as a function of wavelength of the two 100% images in Figures 1a and 1b are very similar, indicating that the differences between the two represent the true reproducibility of the camera and are not due to possible ITF errors.

On the average, the new LWR ITF 30% and 40% ratios are closer to unity than the ratios of spectra processed with the current ITF (Figures 2 and 4). The derived fluxes of a 30% image processed with the new ITF are too low relative to an optimum exposure by 3 to 5% between 2100 and 2800, compared to the current ITF which gives linearity errors of up to 9%. The maximum linearity error of the 40%/100% spectral ratio is 3 to 4% for the new ITF images. This is also improved over the current ITF, which gives errors of up to 10%.

Near 2800 angstroms, the derived fluxes of the 120% image processed with the new ITF were too high relative to the optimum exposure by about 3%. In comparison, the same image processed with the current ITF gave ratios very near unity, with average errors of no more than 2%.

IV. Linearity Errors for High Background Spectra

Figures 5 to 7 illustrate linearity errors for spectra obtained with high backgrounds. The flux ratios averaged over 100 angstrom bandpasses are listed in Table 2. The images in Figure 5 were produced by exposing the camera to a 40% trailed stellar image and then exposing the camera to empty sky to build up the radiation-induced background level. The images in Figures 6 and 7 were produced by exposing the camera to a 40% trailed stellar image and then superimposing a tungsten flood lamp exposure. The radiation background image had a maximum average DN level in the continuum of 175 DN and an average background level of 65 DN. The tungsten flood background images had an average maximum DN level in the continuum of 185 to 200 DN and average background levels of about 110 DN.

The radiation background spectra processed with the new ITF produces a flatter 40%/100% flux ratio than images processed with the current ITF. At the shortest wavelengths the new ITF ratio is closer to unity than the current ITF ratio. At longer wavelengths (roughly 2400 to 3000A) the derived flux of the new ITF 40% spectra is too high by 5 to 10%. This is slightly worse than the current ITF image, which was too high by roughly 3 to 5%.

The tungsten flood background spectra processed with the new ITF also produce flatter 40%/100% flux ratios than images processed with the current ITF. The entire flux ratio for the new ITF images is increased and, on the average, is closer to unity. For the new ITF images, an individual 100 angstrom binned flux ratio can have linearity errors of 3 to 10%. In comparison, the current ITF images have linearity errors of 6 to 18%. The individual variations in the 100 angstrom bins are probably due to the inherent noisiness of the spectra.

V. Linearity Errors for November 1978

The under-exposed spectra processed with the new ITF produce flux ratios which are closer to unity than the spectra processed with the current ITF (see Figures 8 to 10). The new ITF ratios exhibit a slight curvature as a function of wavelength. The wavelength region between about 2100 to 2500 is enhanced relative to the wavelength region between about 2500 to 3000 angstroms. For example, at the short wavelength end, the new ITF 30%/100% ratio is too high by 2 to 4%, while near 2800 it is depressed by about 3%. These errors are considerably improved compared to the 4-10% errors seen with the current ITF processing.

The 120% spectrum processed with the current ITF shows linearity errors of 2 to 3% (Figure 11a). The derived flux has a slight slope as a function of wavelength. Below 2500 the flux is too low by up to 2%, while above this point the flux is too high by about 2%. The 120% spectra processed with the new ITF shows linearity errors of 2% to 5% in the region between about 2500 and 3000 angstroms (Figure 11b). Thus the linearity of the November 1978, 120% spectrum appears to be slightly poorer when processed with the new ITF compared to the current ITF. It should be noted that the 120% spectrum uses extrapolated ITFs for pixels between 2545 angstroms and 2900 angstroms.

VI Summary

On the average, the new LWR ITF improves the linearity of trailed low dispersion LWR spectra. The reproducibility of the current and new ITF is comparable. The linearity of under-exposed low dispersion trailed spectra with low and high backgrounds is significantly improved. The linearity of the 120% spectra is slightly worse with the new ITF, but only by a couple of percent.

The new ITF also improves the linearity of the 1978 images, despite the fact that they were taken 5 years prior to the new ITF observations. The linearity may be slightly poorer for the 1978 data compared to the 1983 data, but the new ITF still improves the linearity of under-exposed spectra. The linearity of the 120% spectra, taken in late 1978, is slightly worse when processed with the new LWR ITF compared to the current ITF. The LWR camera appears to have undergone a change in its sensitivity during the first six months following launch. If the camera characteristics changed as a function of time, then it is probable that some time prior to November 1978 the current ITF may be more appropriate than the 'new' ITF.

References

Sonneborn, G. and Garhart, M. 1983, IUE NASA Newsletter, No. 23, p 23.

Table 1

Binned Flux Ratios for September 1983
(Figures 1 to 4)

Central Wavelength	100% / 100%		30% / 100%		40% / 100%		120% / 100%	
	Current ITF	New ITF	Current ITF	New ITF	Current ITF	New ITF	Current ITF	New ITF
2100	1.008	1.001	1.018	0.954	1.048	1.018	1.007	1.011
2200	1.013	1.008	1.023	0.981	1.053	1.040	1.007	1.011
2300	1.008	1.002	1.056	0.981	1.039	1.003	0.985	0.995
2400	1.009	1.002	1.063	0.969	1.069	1.006	0.992	1.013
2500	1.005	1.000	1.084	0.962	1.100	1.004	0.996	1.021
2600	1.000	0.996	1.091	0.976	1.098	0.998	0.997	1.016
2700	1.001	1.002	1.090	0.959	1.069	0.966	0.997	1.018
2800	1.002	1.005	1.071	0.967	1.063	0.970	1.011	1.031
2900	1.002	1.001	1.072	0.977	1.059	0.967	0.990	1.013
3000	1.011	1.007	1.073	1.000	1.048	0.976	1.003	1.016
3100	1.040	1.034	1.022	1.014	0.971	0.984	1.001	1.003
Deviations:								
Ave (%)	0.90	0.60	6.03	2.62	6.14	1.91	0.65	1.44
RMS (%)	0.46	0.36	2.18	0.97	2.15	0.77	0.26	0.53

Note: Ave Dev = ave[abs(1-FR)]

RMS Dev = $[\Sigma (FR-1)^2]^{1/2} / (n-1)$

Table 2
Binned Flux Ratios for High Background Spectra
(Figures 5 to 7)

Central Wavelength	HD 60753 (40% + Rad Bkg) / 100%		HD 60753 (40% + T-fld Bkg) / 100%		HD 6300 (40% + T-fld Bkg) / 100%	
	Current ITF	New ITF	Current ITF	New ITF	Current ITF	New ITF
2100	0.932	0.981	0.752	0.892	0.705	0.820
2200	0.904	0.970	0.834	0.954	0.961	1.104
2300	0.950	1.046	0.910	1.077	0.820	1.024
2400	1.006	1.079	0.859	0.992	0.883	1.029
2500	1.056	1.111	0.903	0.996	0.905	0.960
2600	1.021	1.074	0.937	1.003	0.891	0.952
2700	1.036	1.085	0.936	0.997	0.954	1.007
2800	1.041	1.068	0.905	0.976	0.884	0.926
2900	1.004	1.049	0.939	1.051	0.899	1.013
3000	0.998	1.090	0.916	1.031	0.925	1.058
3100	1.068	1.118	1.104	1.210	1.121	1.227
Deviations:						
Ave (%)	4.07	6.99	18.69	5.14	11.76	7.31
RMS (%)	1.66	2.52	4.06	2.61	4.49	3.30

Table 3
Binned Flux Ratios for November, 1978
(Figures 8 to 11)

Central Wavelength	30% / 100%		40% / 100%		60% / 100%		120% / 100%	
	Current	New	Current	New	Current	New	Current	New
2100	1.061	1.044	1.033	1.013	1.040	1.042	0.977	1.006
2200	1.039	1.060	1.007	1.009	1.021	1.036	0.976	1.009
2300	1.066	1.042	1.040	1.007	1.036	1.021	0.990	1.008
2400	1.090	1.019	1.071	1.009	1.031	0.999	0.997	1.027
2500	1.095	1.000	1.075	1.001	1.046	1.011	1.000	1.041
2600	1.075	0.994	1.073	1.002	1.040	1.000	1.017	1.051
2700	1.090	0.991	1.065	0.976	1.032	0.979	1.018	1.051
2800	1.063	0.960	1.059	0.976	1.034	0.995	1.016	1.040
2900	1.074	0.975	1.089	1.002	1.041	0.984	1.014	1.024
3000	1.051	0.986	1.071	1.000	1.038	0.996	1.005	1.028
3100	1.004	0.998	1.061	1.043	1.058	1.045	1.013	1.020
Deviations:								
Ave (%)	6.44	2.37	5.85	1.22	3.79	1.84	1.30	2.77
RMS (%)	2.29	1.01	2.08	0.58	1.29	0.80	0.50	1.06

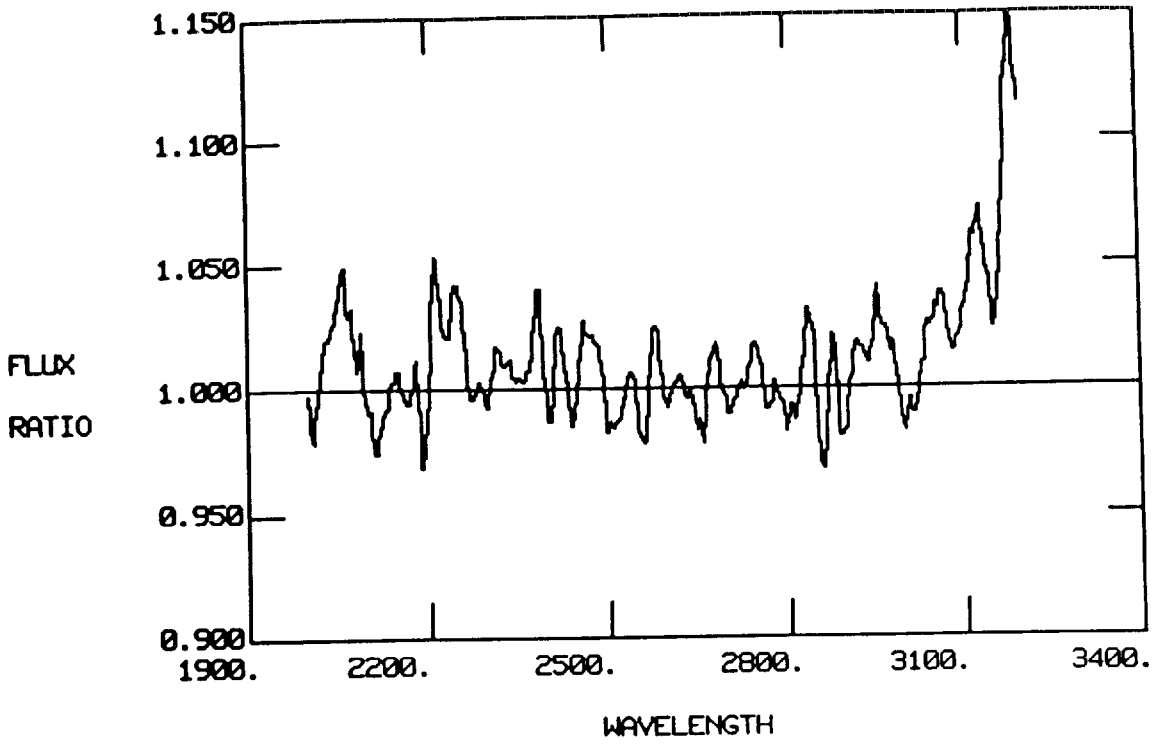

Figure 1a. Reproducibility - 100% / 100%
September, 1983
Current LWR ITF
LWR 16785 / LWR 16789

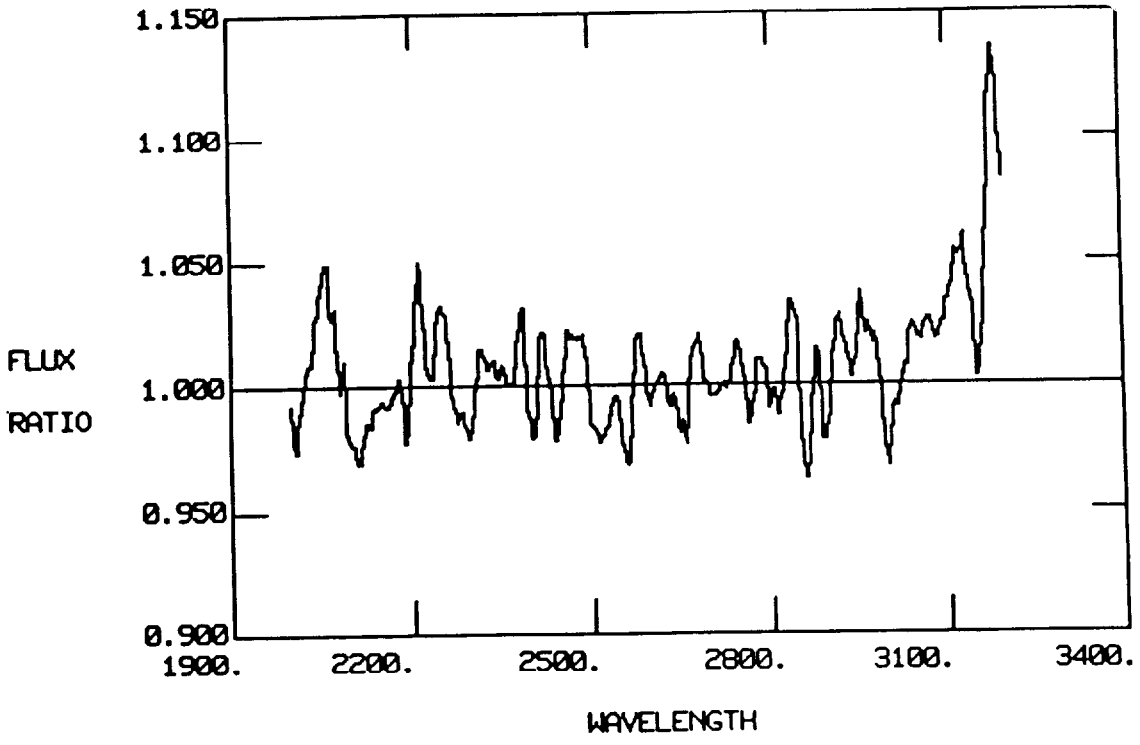

Figure 1b. 100% / 100% in September, 1983
New LWR ITF
LWR 16785 / LWR 16789

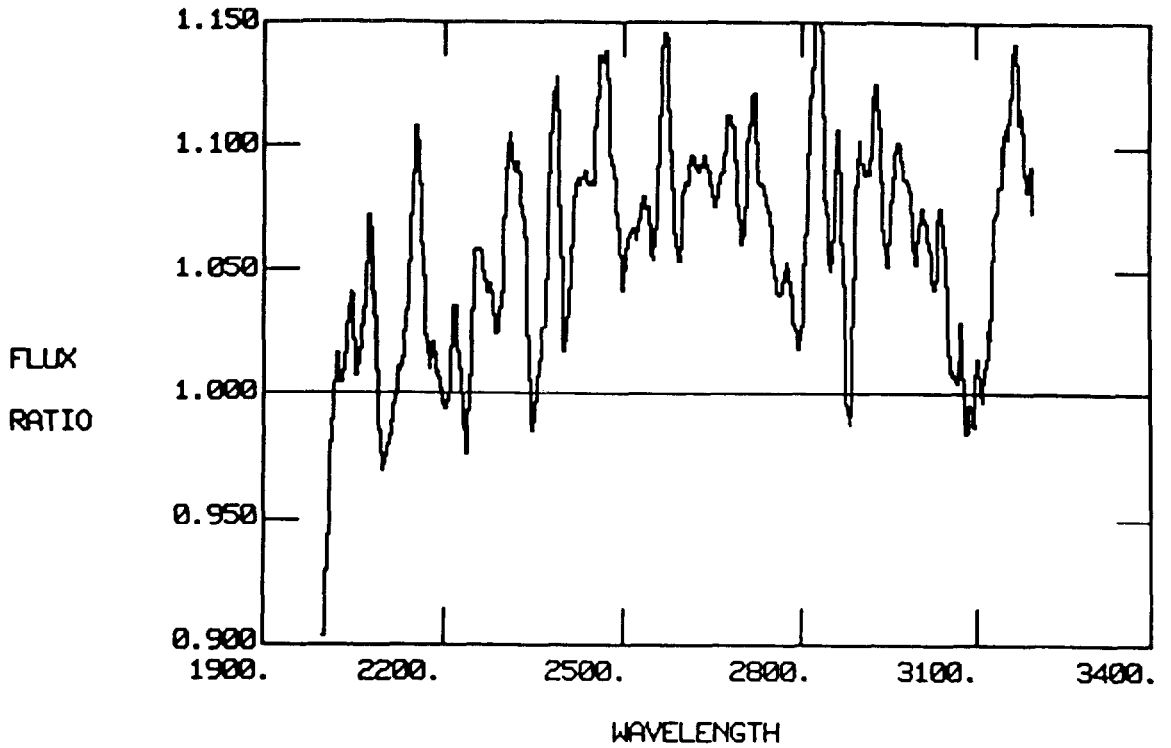

Figure 2a. 30% / 100% in September, 1983
Current LWR ITF
LWR 16786 / LWR 16789

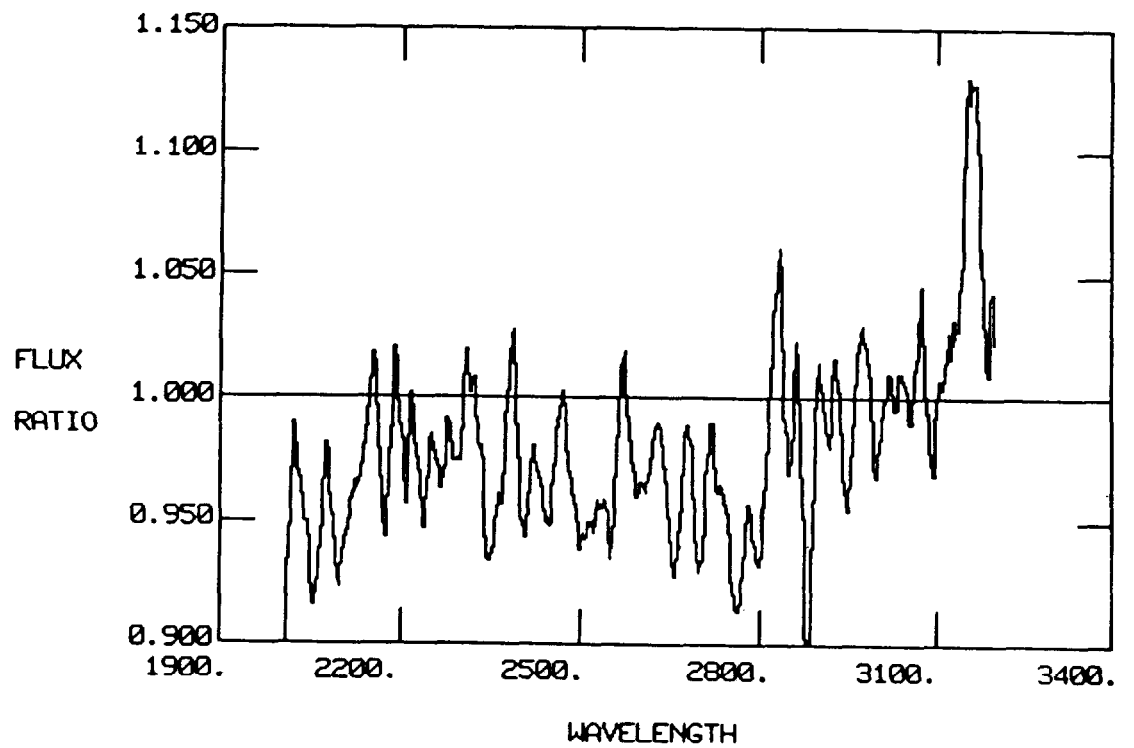

Figure 2b. 30% / 100% in September, 1983
New LWR ITF
LWR 16786 / LWR 16789

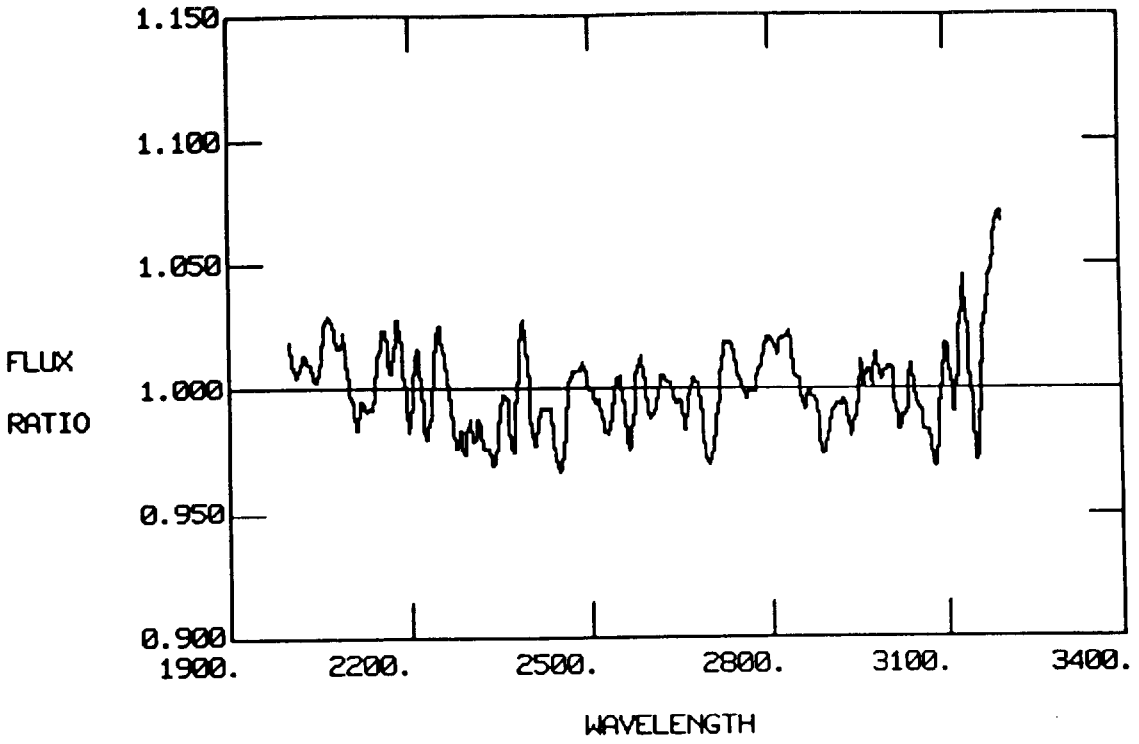

Figure 3a. 120% / 100% in September, 1983
Current LWR ITF
LWR 16787 / LWR 16789

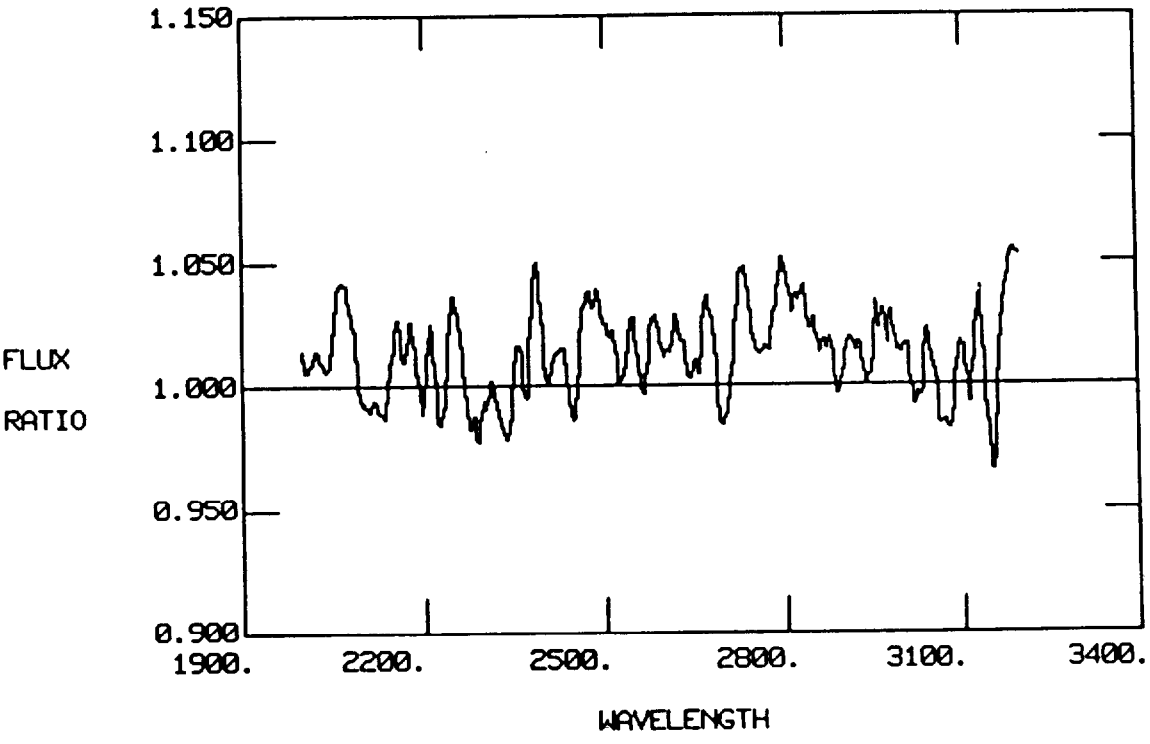

Figure 3b. 120% / 100% in September, 1983
New LWR ITF
LWR 16787 / LWR 16789

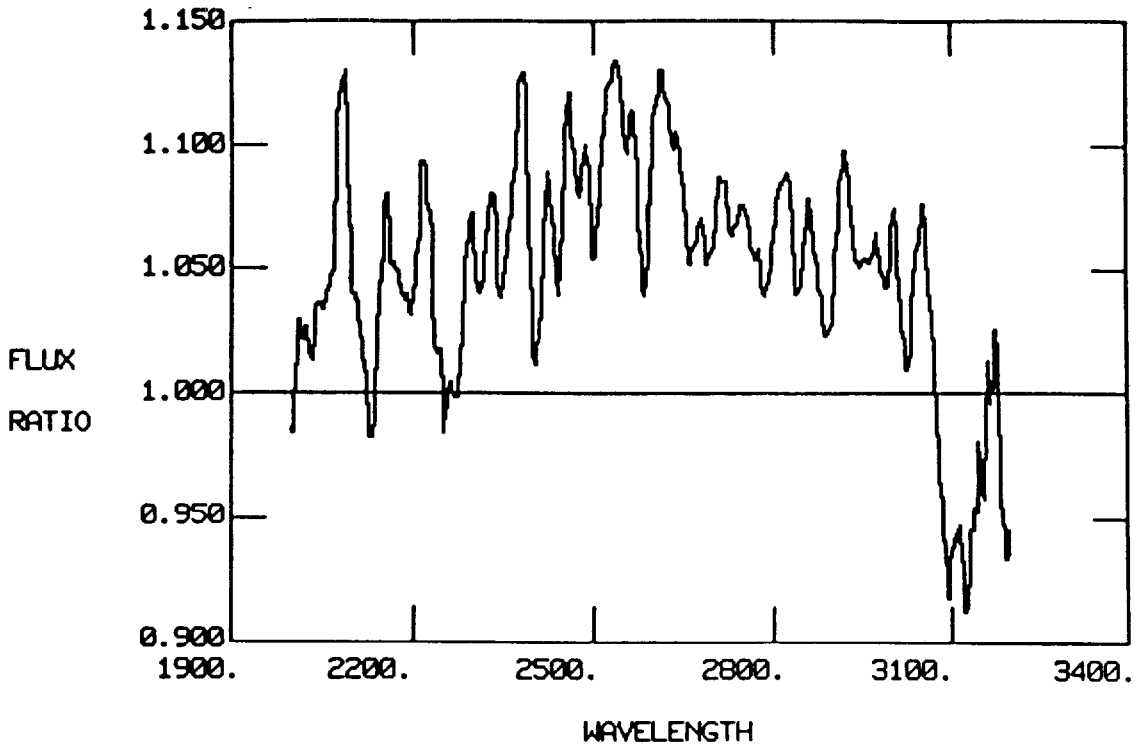

Figure 4a. 40% / 100% in September, 1983
Current LWR ITF
LWR 16788 / LWR 16789

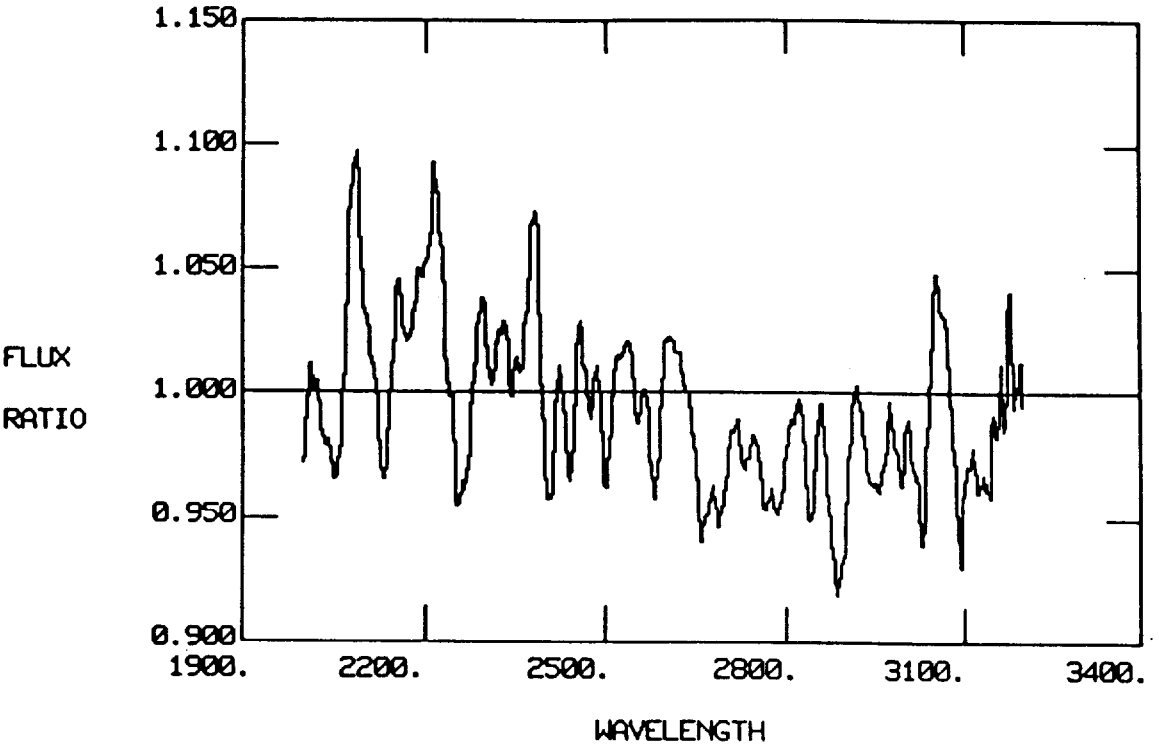

Figure 4b. 40% / 100% in September, 1983
New LWR ITF
LWR 16788 / LWR 16789

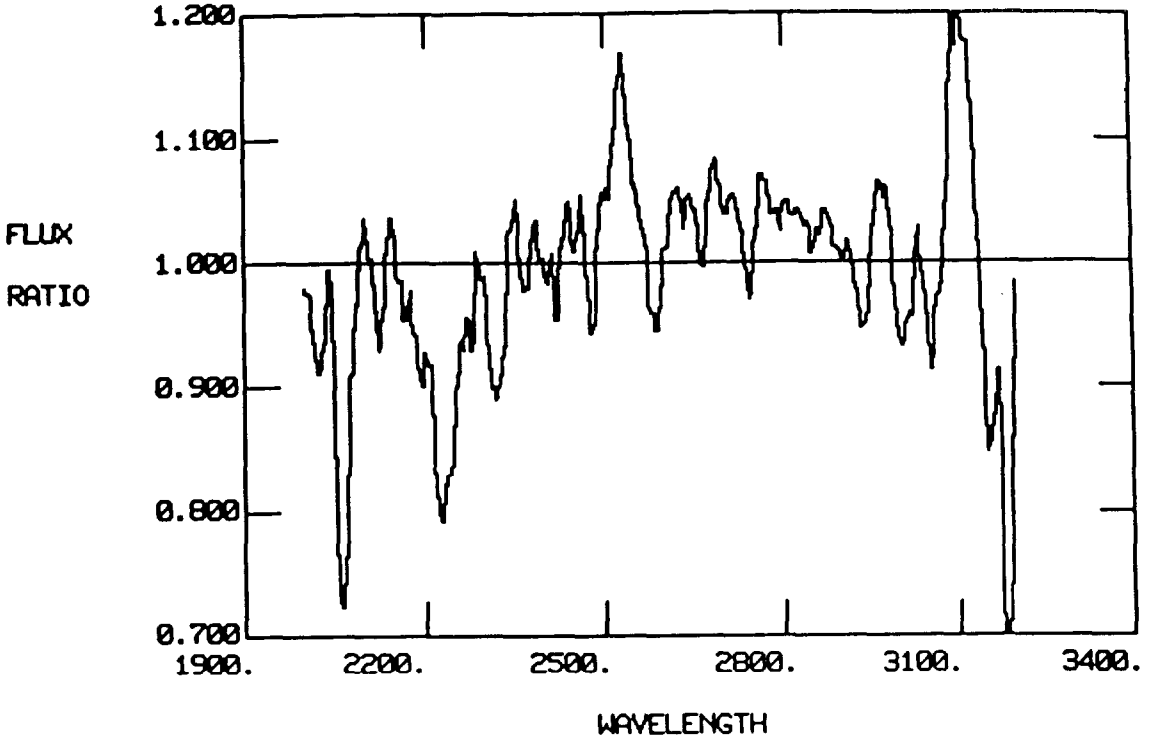

Figure 5a. (40% + high radiation bkg) / 100%
March, 1984
Current LWR ITF
LWR 17280 / 17250

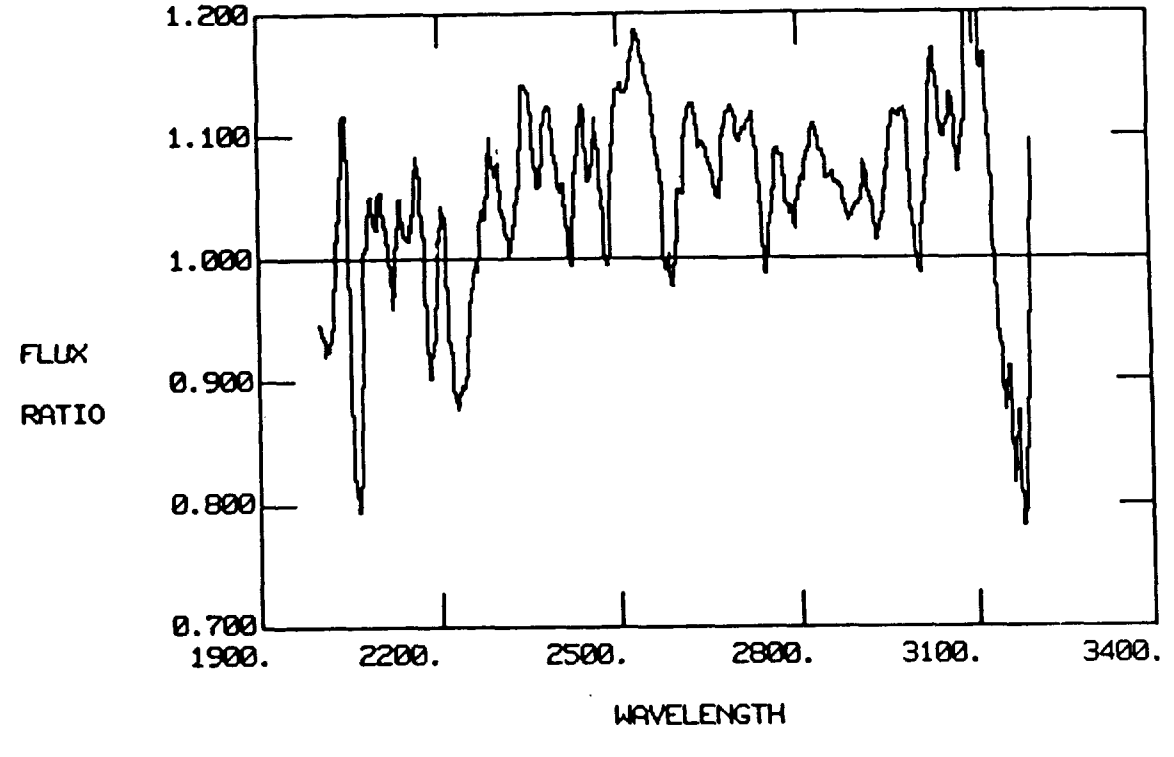

Figure 5b. (40% + radiation background) / 100%
March, 1984
New LWR ITF
LWR 17280 / LWR 17250

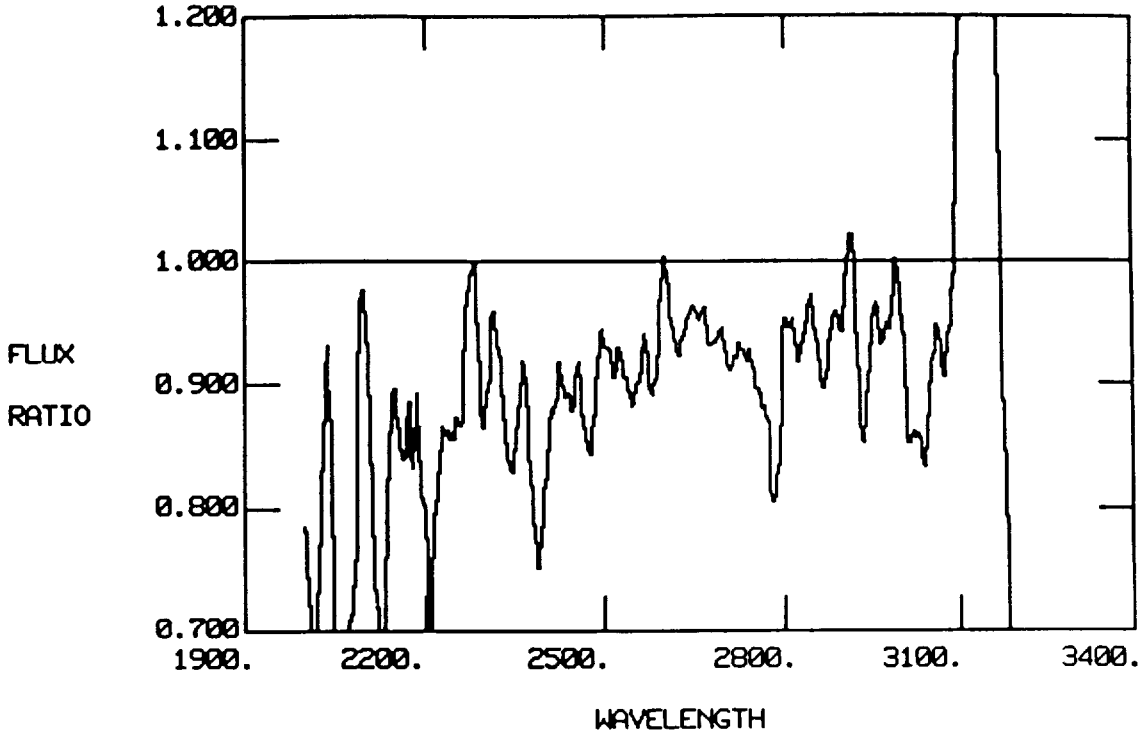

Figure 6a. (40% + T-flood background) / 100%
February, 1984
Current LWR ITF
LWR 17249 / LWR 17250

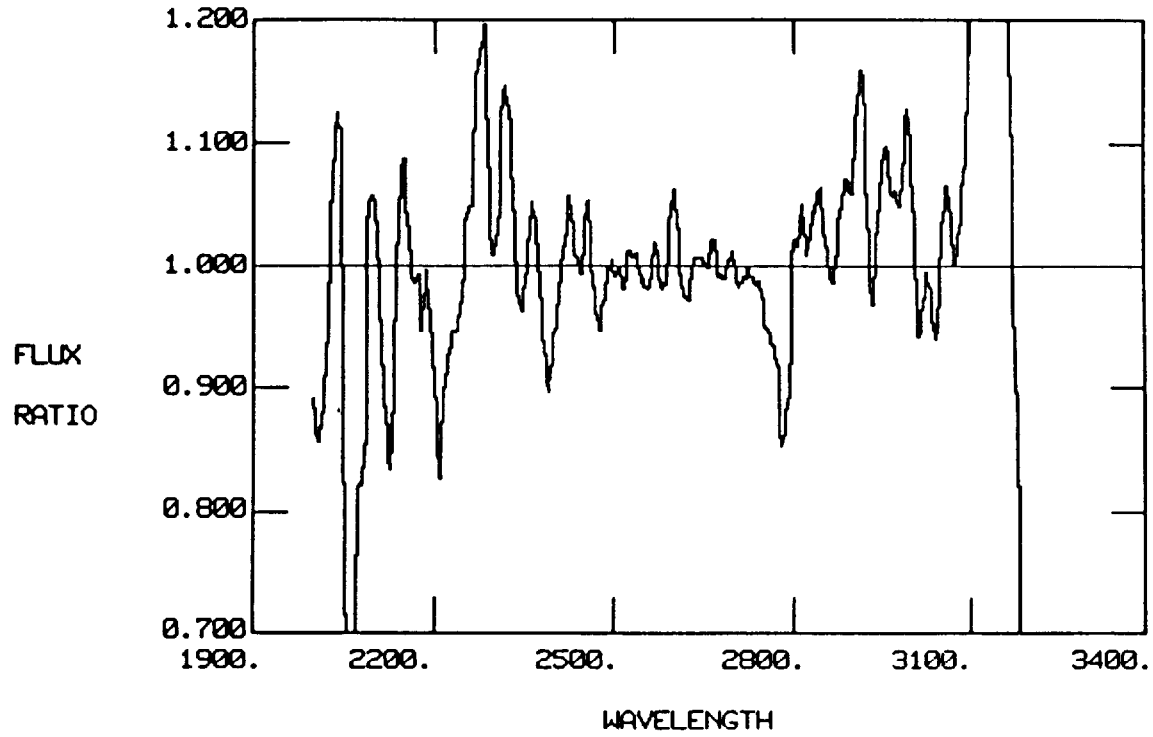

Figure 6b. (40% + T-flood background) 100%
February, 1984
New LWR ITF
LWR 17249 / LWR 17250

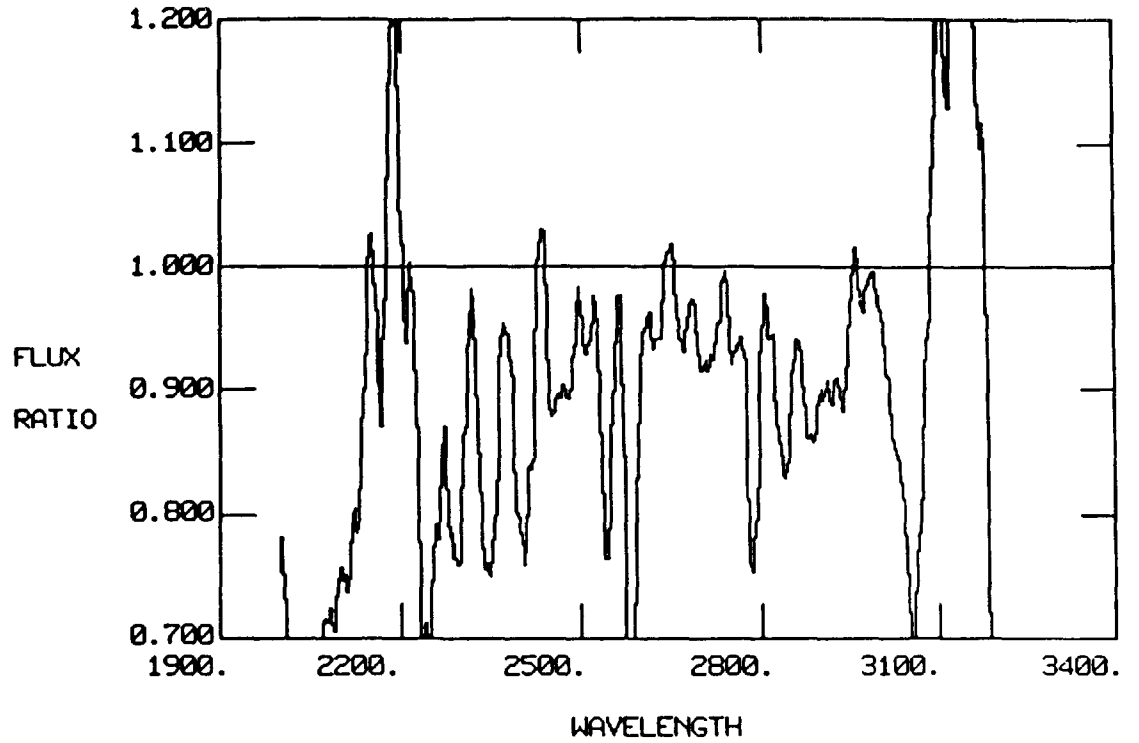

Figure 7a. (40% + T-flood background) / 100%
HD 6300 in November, 1983
Current LWR ITF
LWR 17162 / LWR 17163

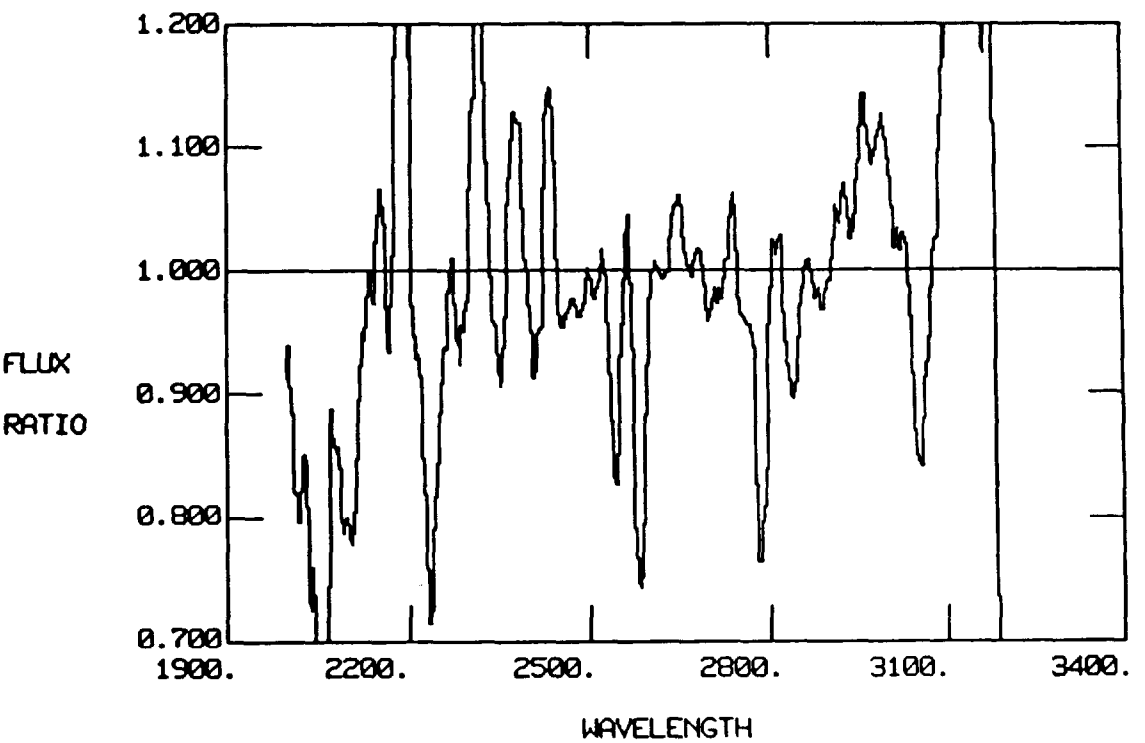

Figure 7b. (40% + T-flood background) / 100%
HD 6300 in November, 1983
New LWR ITF
LWR 17162 / LWR 17163

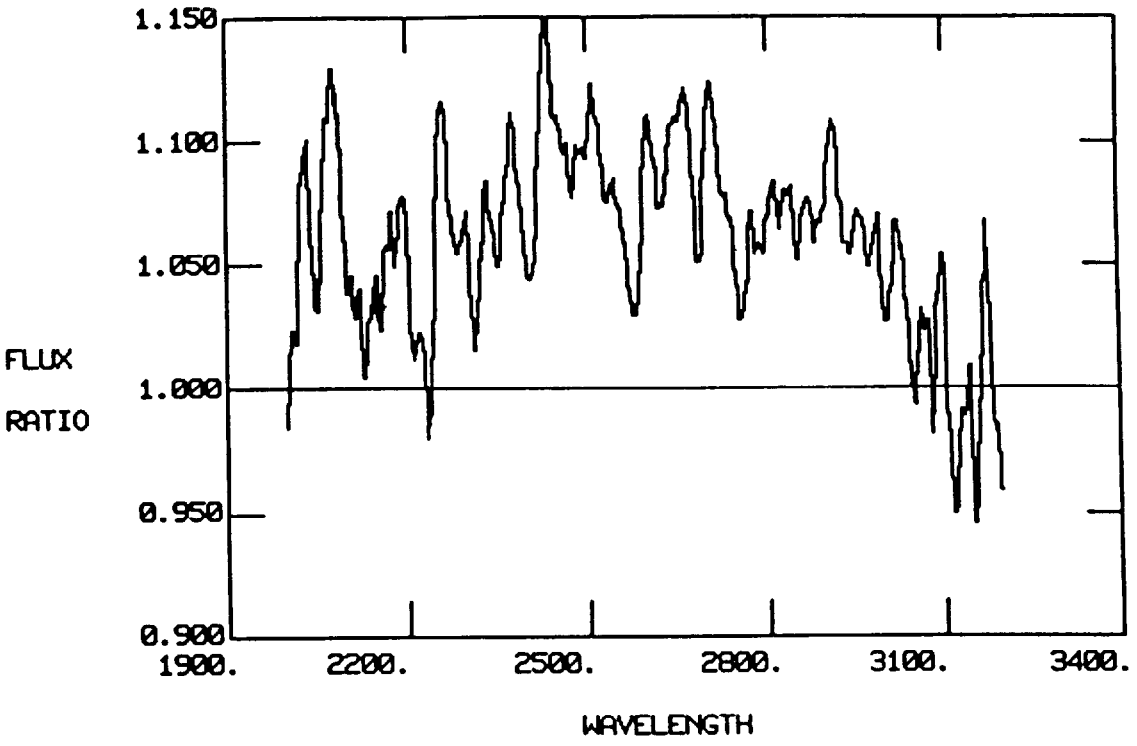

Figure 8a. 30% / 100% in November, 1978
Current LWR ITF
LWR 2825 / LWR 2822

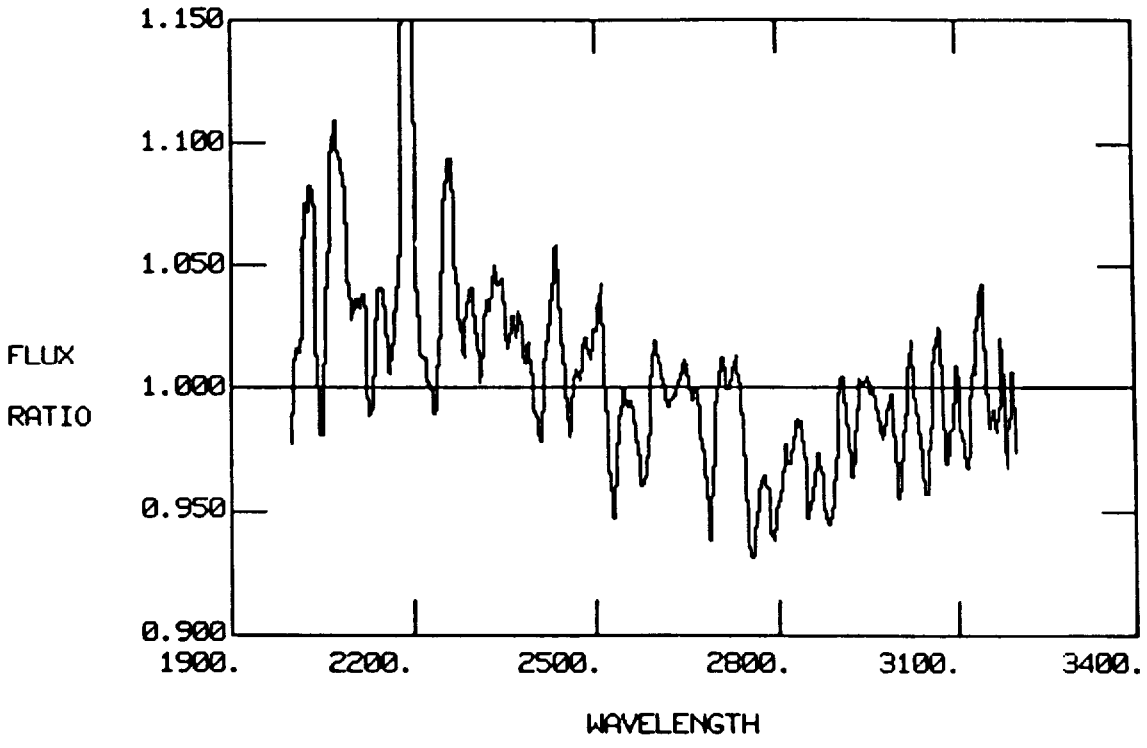

Figure 8b. 30% / 100% in November, 1978
New LWR ITF
LWR 2825 / LWR 2822

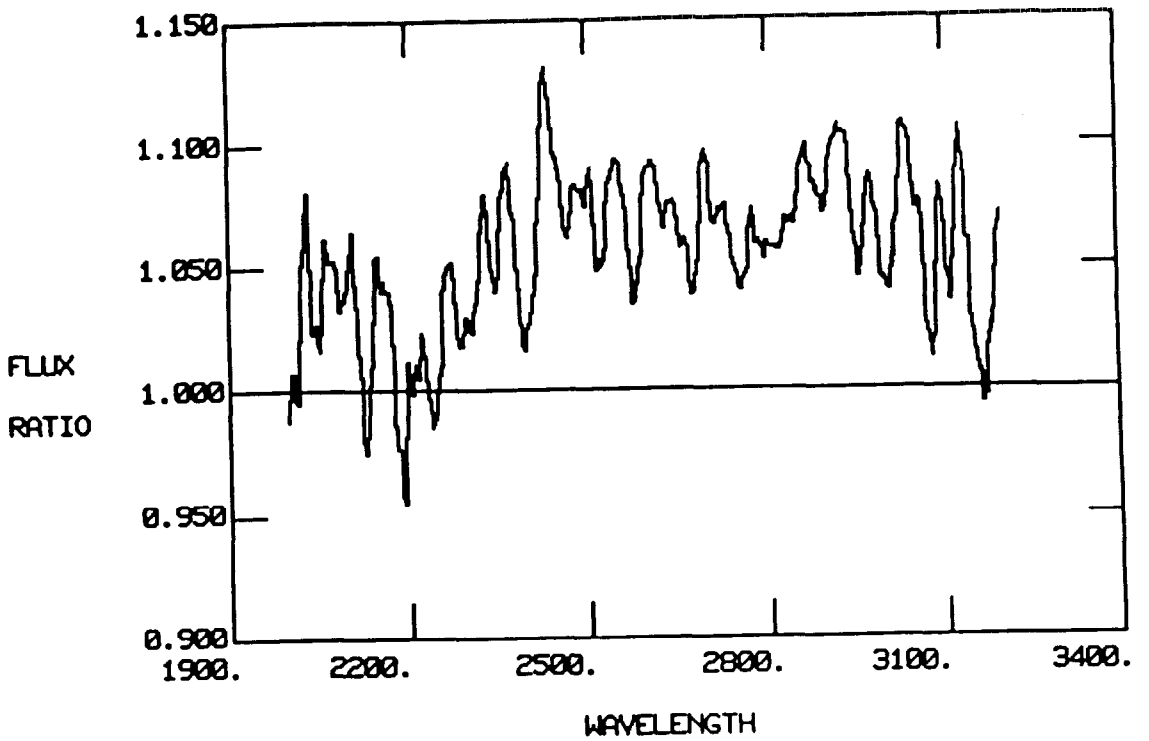

Figure 9a. 40% / 100% in November, 1978
Current LWR ITF
LWR 2824 / LWR 2822

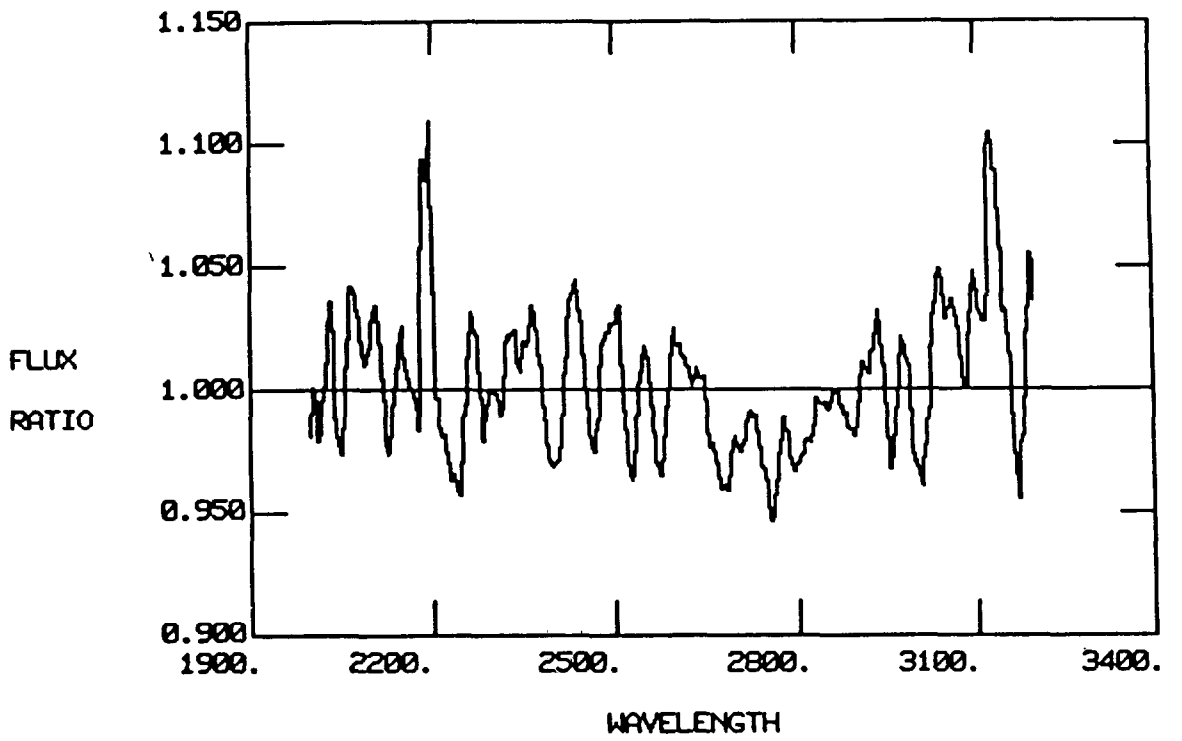

Figure 9b. 40% / 100% in November, 1978
New LWR ITF
LWR 2824 / LWR 2822

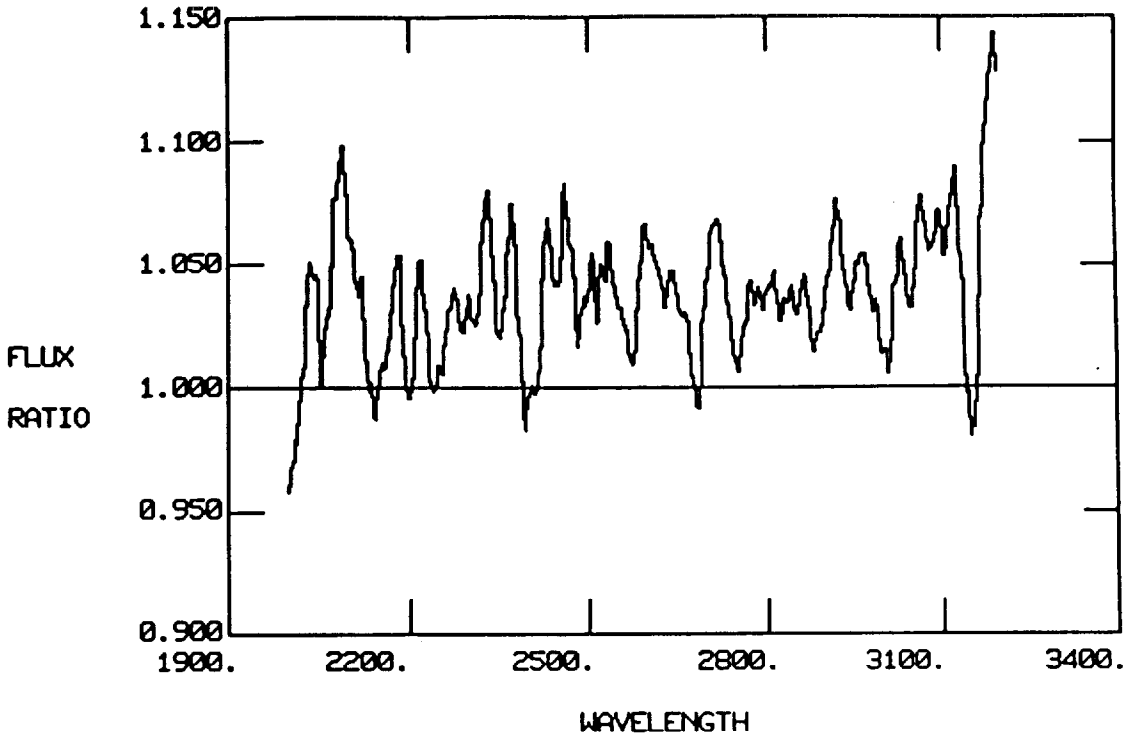

Figure 10a. 60% / 100% in November, 1978
Current LWR ITF
LWR 2826 / LWR 2822

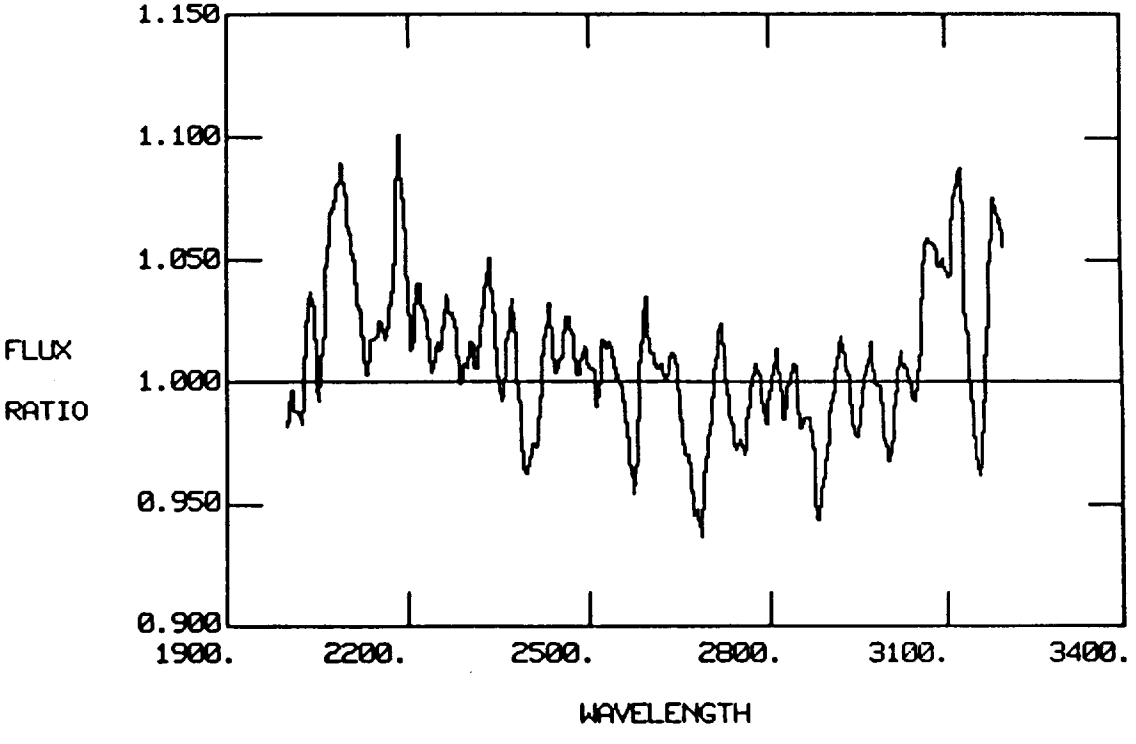

Figure 10b. 60% / 100% in November, 1978
New LWR ITF
LWR 2826 / LWR 2822

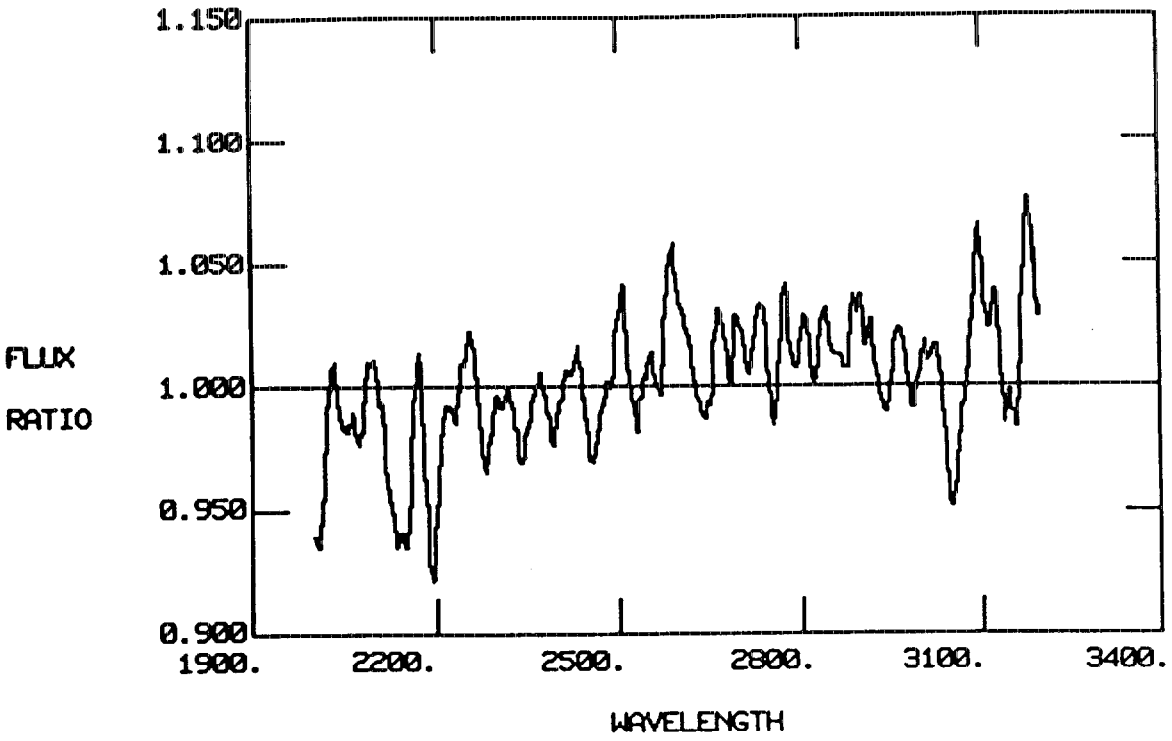

Figure 11a. 120% / 100% in November, 1978
Current LWR ITF
LWR 2830 / LWR 2822

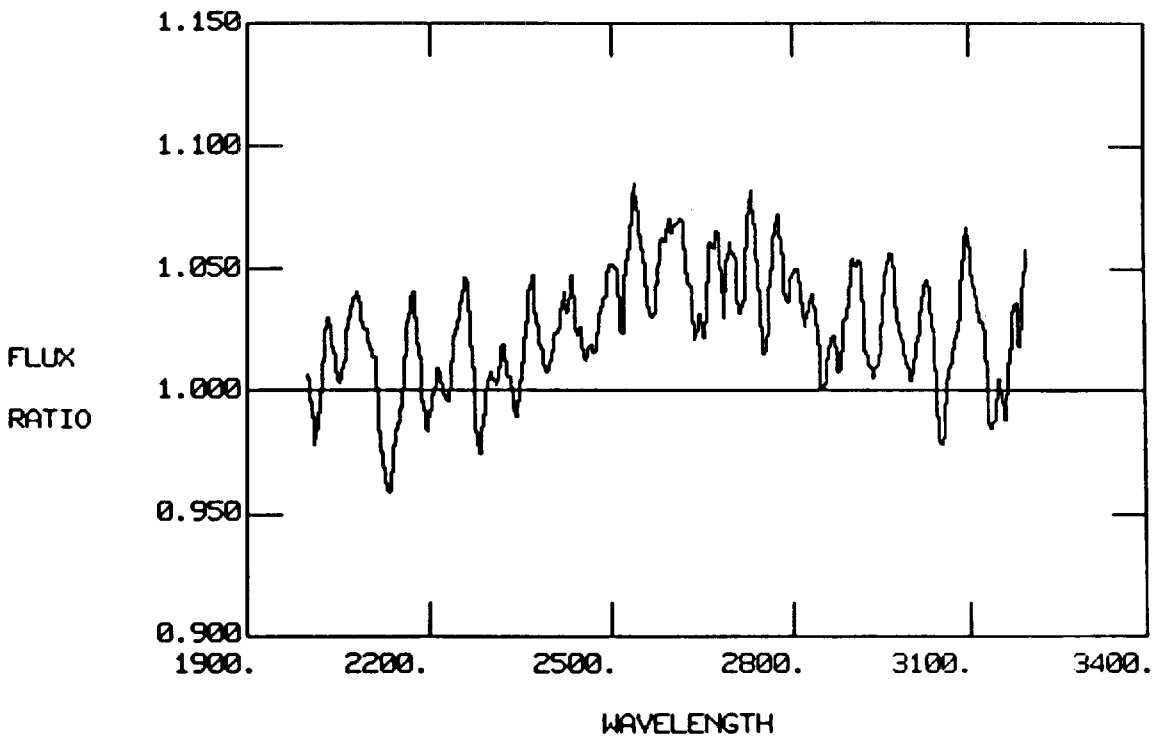

Figure 11b. 120% / 100% in November, 1978
New LWR ITF
LWR 2830 / LWR 2822