Review of the FES Calibration

During the past year, three papers based on IUE FES photometry have appeared (Rucinski et al. 1980; Rahe et al. 1980; and Guinan and Sion 1981). In view of the interest in this instrument, we decided to review and, if possible, to improve the FES calibration. There are two versions of an FES calibration, one by Stickland (1980) and the other by Holm and Crabb (1979). Both calibrations are efforts to correct for the instrumental dead time and to derive a color correction in order that accurate estimates of the V magnitude can be obtained.

The Holm and Crabb calibration (GSFC) has the form

$$V + 0.24\ (B-V) = -2.5\ \mathrm{LOG}\left[\frac{C}{1-1.6\mathrm{E}{-4}\ C^{0.781}}\right]^{1} + K$$

$$\text{WHERE} \qquad K = \begin{cases} 16.58^{*} & \text{OVERLAP mode} \\ 11.20^{*} & \text{UNDERLAP mode} \end{cases}$$

and C = FES counts in fast track mode.

The Stickland calibration (VILSPA) has the form

$$V + 0.28\ (B-V) = -2.58\ \mathrm{LOG}(C)\ -8.704\mathrm{E}{-11}\ C^{2.177} + K$$

$$\text{WHERE} \qquad K = \begin{cases} 16.71 & \text{OVERLAP mode} \\ 11.38^{*} & \text{UNDERLAP mode} \end{cases}$$

and C = FES counts in fast track mode.

* Values as revised in this report.

To evaluate the accuracy of these calibrations we tested both on a data base of 625 FES observations that has been built up at Goddard during the first three years of operations. These observations were of stars that were selected

to be non-variable and to have weak or absent emission lines. For both calibrations, non-zero mean errors were found which were used to correct the K constants to the values given above and to derive a K constant for underlap mode for Stickland's calibration. The RMS differences between the measured FES magnitudes and the color corrected V magnitudes are given in Table 1.

Table 1. CALIBRATION ERRORS

Mode	No. Obs.	RMS Errors	
		GSFC	VILSPA
Overlap	599	0.081	0.078
Underlap	126	0.081	0.091

We evaluated the reproducibility of the FES to determine whether these errors are caused primarily by instrumental limitations or by the assumed functional dependence of the calibration. Reproducibility errors derived from repeat observations of the standard stars used for monitoring the UV sensitivity of the instrument are given in Table 2. The predicted sigma in the last column is based on the square root of the number of counts and on the number of measurements averaged.

Table 2. REPRODUCIBILITY ERRORS

Star	C	No. Obs.	Calibration Errors	RMS	Pred. Sigma
HD 60753	7700	65	0.001	0.036	0.002
HD 93521	6000	61	0.032	0.036	0.003
+75 325	650	69	-0.034	0.031	0.008
+28 4211	270	75	-0.045	0.054	0.013
+33 2642	190	37	-0.074	0.043	0.015

It is clear that the errors in the calibration are much larger than the errors in reproducibility. Possible error sources in the calibration include inaccuracies in the dead time correction, errors in the color term, errors in the published UBV magnitudes, and contamination by field stars and by sky background. We believe that most of the error comes from the dead time correction and the color term. Figures 1 and 2 of Holm and Crabb (1979) suggest that there are systematic errors with both magnitude and color. For very red stars, the color the coefficient of B-V is considerably different than for the blue stars, perhaps

being as negative as -0.2. Sky background in the FES contributes 0.2 to 1.0 counts plus any scattered earth light. That usually is insignificant.

The difference between the observed and predicted reproducibility may be caused by variations in contamination by field stars as the S/C rotates during the course of a year, by time dependent sensitivity changes, by temperature dependent sensitivity changes, or by variations in focus.

Our analysis shows that the FES gives estimates of the visual magnitude with RMS errors of 0.08 mag. The RMS errors associated with reproducibility are better, being 0.04 mag. Observers of variable stars should assume the larger errors apply since these are probably associated with systematic errors in the dead time correction and in the color term. In the future, we intend to derive a better calibration.

Al Holm and Glenn Rice

1981 August 27

References

Guinan, E.F., and Sion, E.M. 1981, Information Bull. on Variable Stars, No. 1922.

Holm, A., and Crabb, W. 1979, NASA IUE Newsletter No. 7, 40.

Rahe, J., Boggess, A., Drechsel, H., Holm, A., and Krautter, J. 1980, Astron. Astrophys. 88, L9.

Rucinski, S.M., Gondhalekar, P., Pringle, J.E., and Whelan, J.A.J. 1980, Information Bull. on Variable Stars, No. 1844.

Stickland, D. 1980, ESA IUE Newsletter No. 5. 30.