

## REFERENCES

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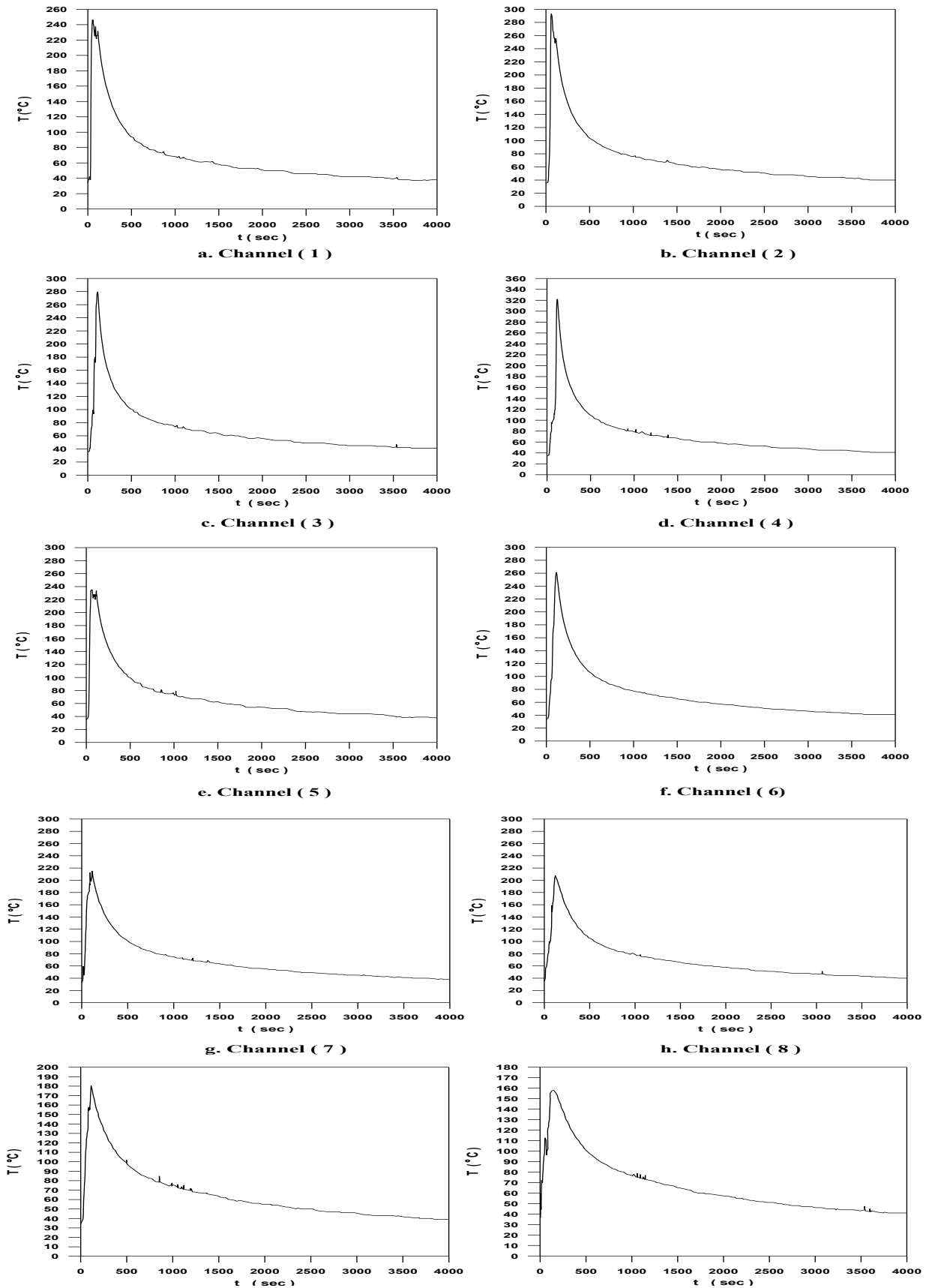


Fig. 9. Measured Temperature History of Plate (1), Pass (1)

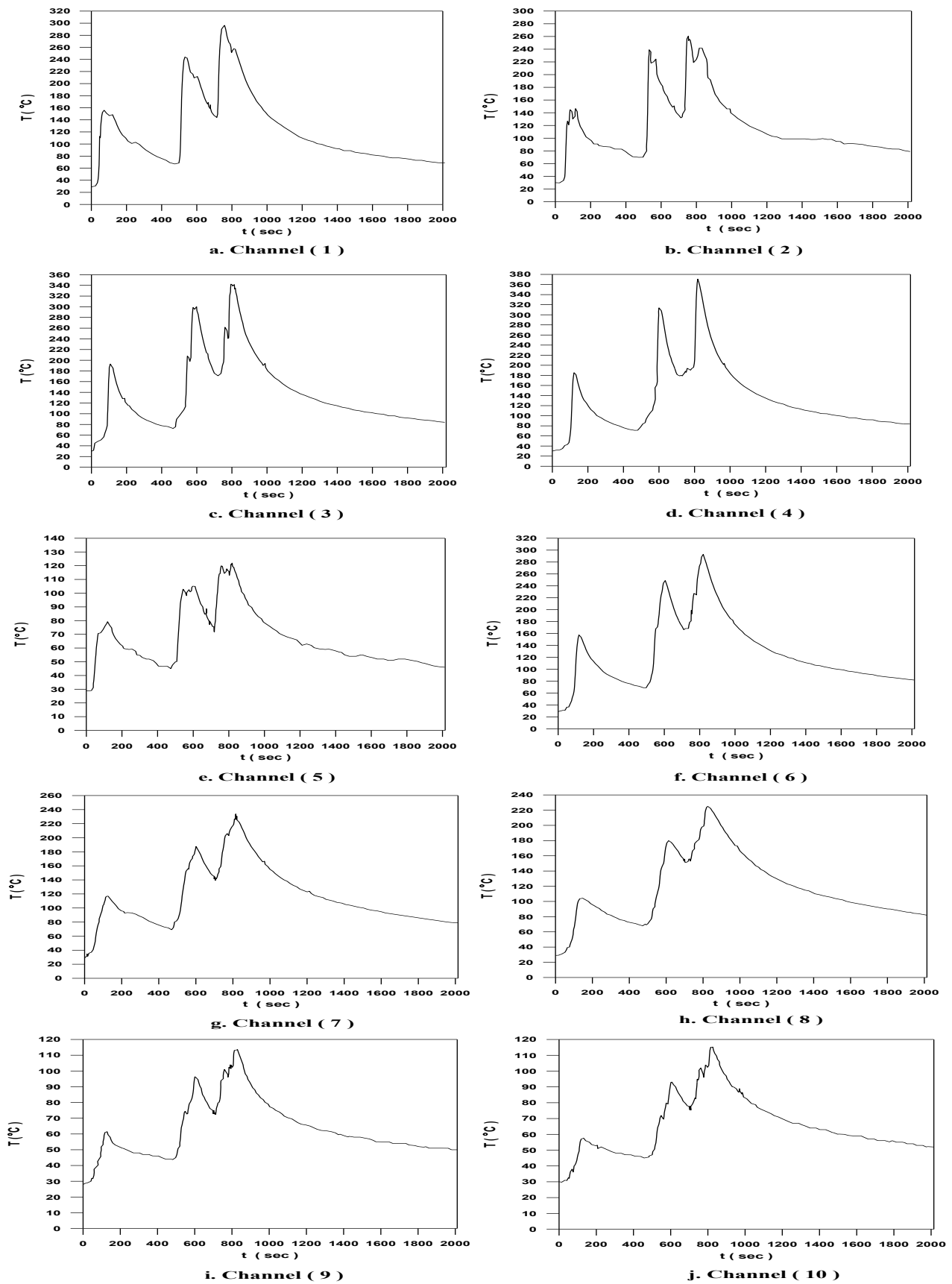


Fig. 10. Measured Temperature History of Plate (2), Multipass (Three passes)

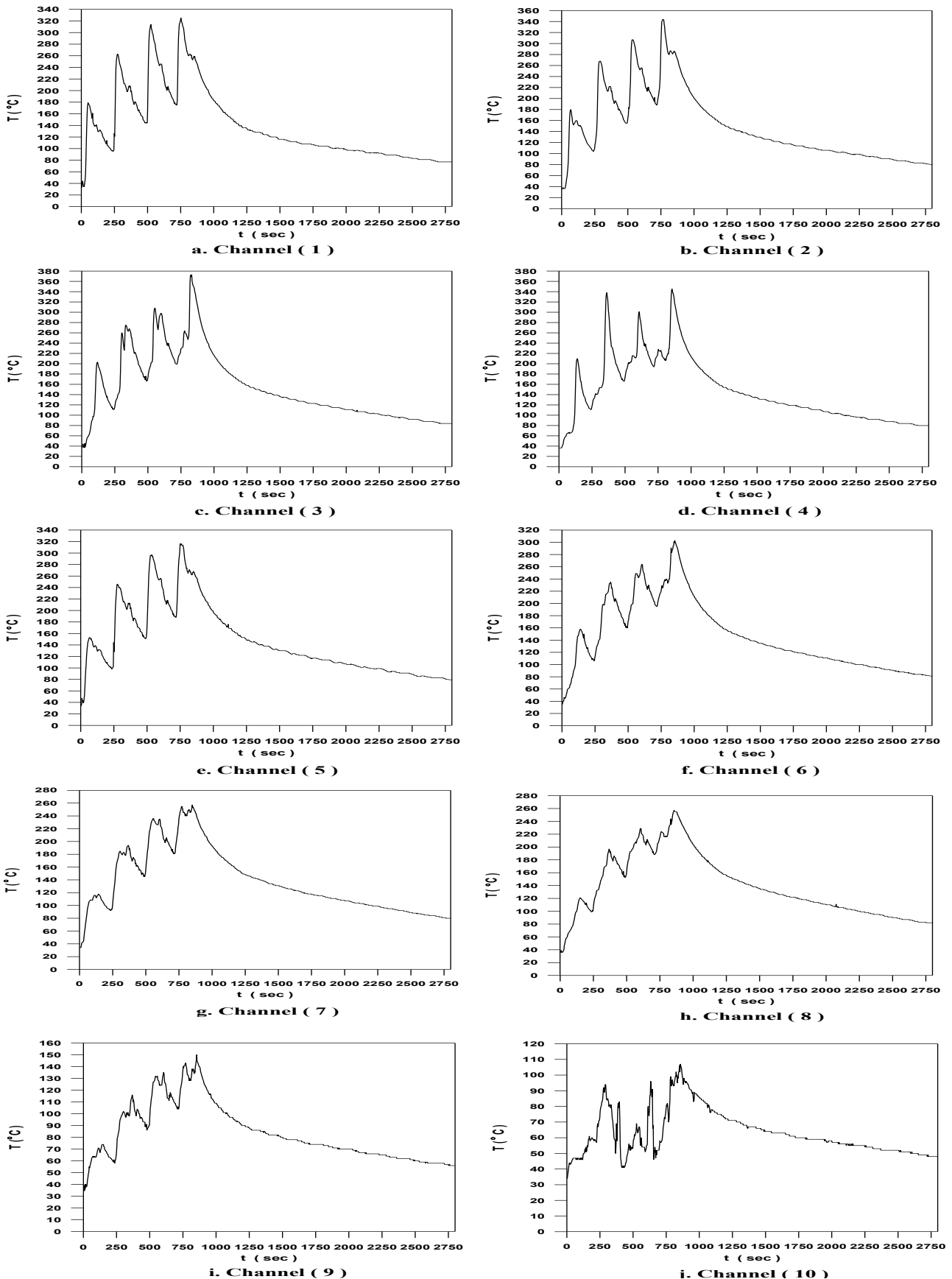


Fig. 11. Measured Temperature History of Plate (3), Multipass (Four passes)

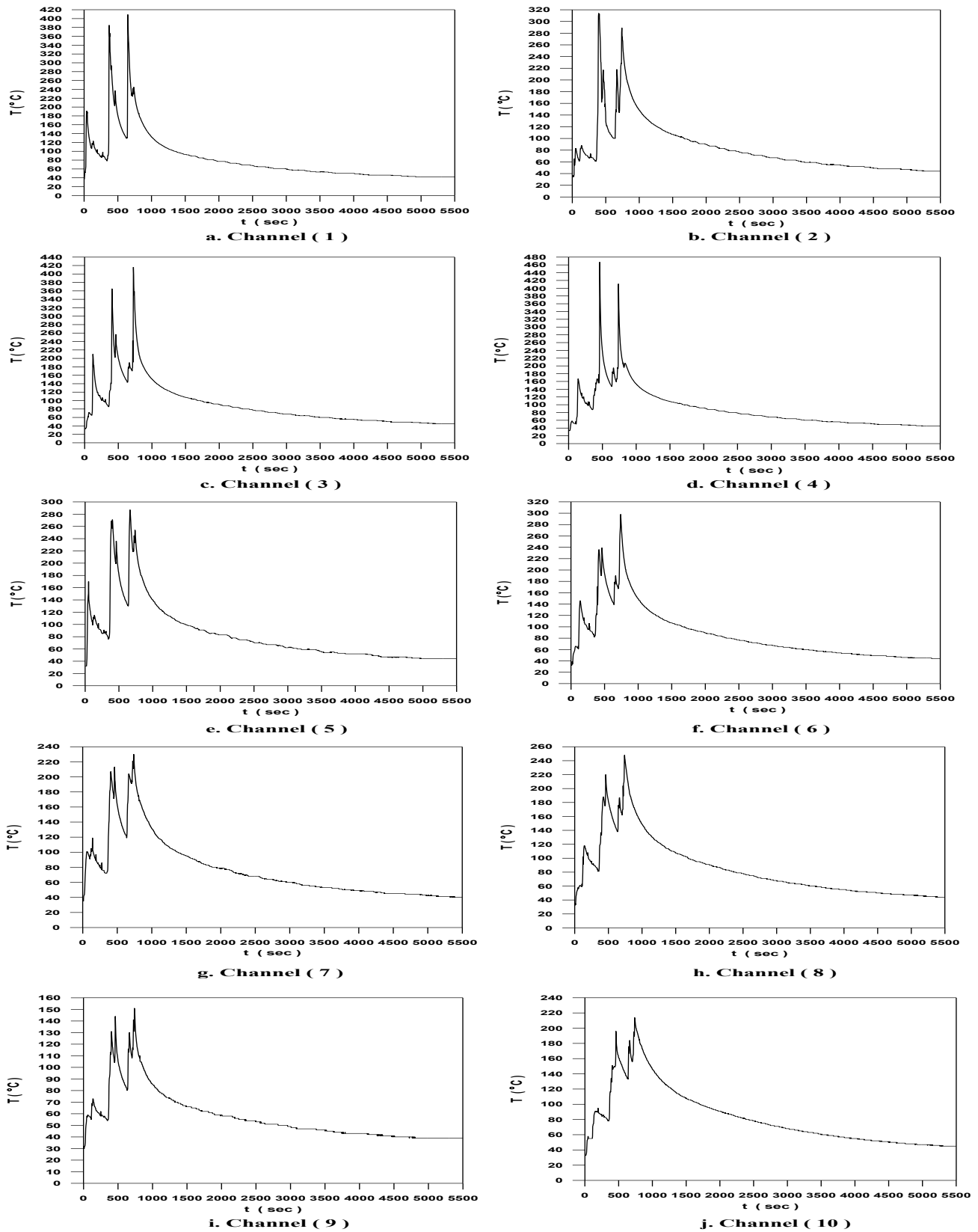


Fig. 12. Measured Temperature History of Plate (4), Multipass (Three passes)

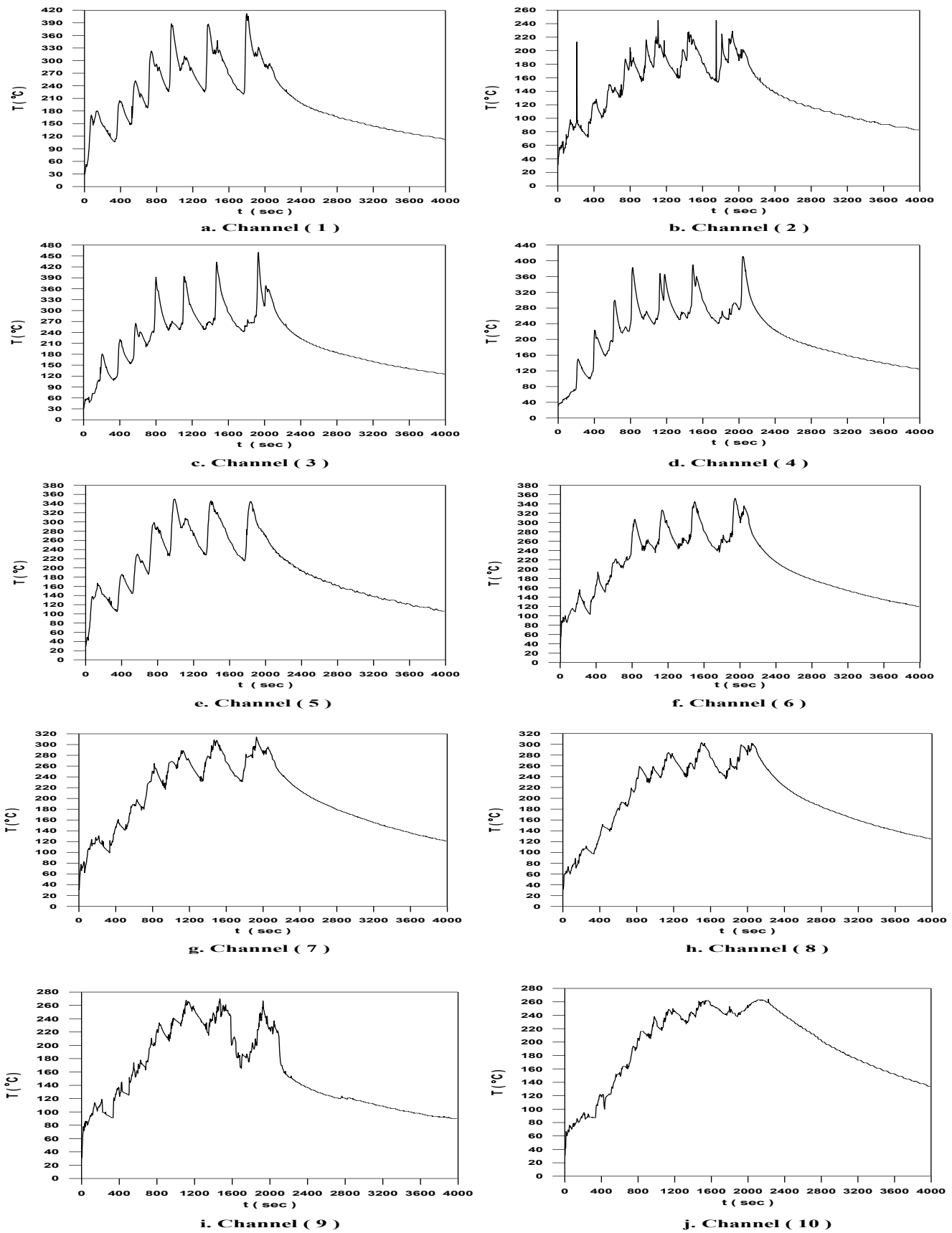


Fig. 13. Measured Temperature History of Plate (5), Multipass (seven passes)

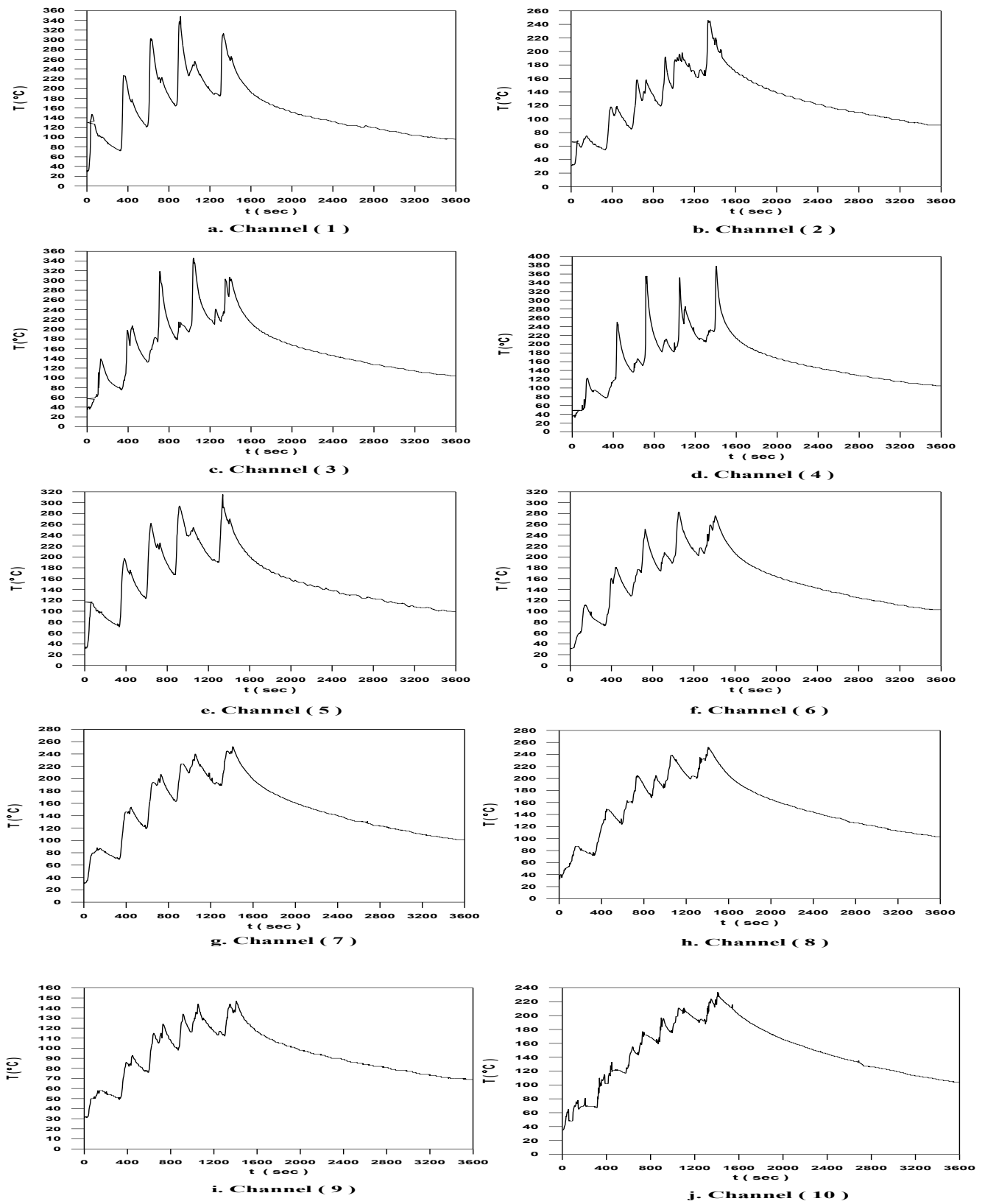


Fig. 14. Measured Temperature History of Plate (6), Multipass (Five passes)

## NOMENCLATURE

### Latin Symbols

Symbol	Definition	Unit
H	Length of plate	mm
i	Finite difference index in the r-direction	—
I	Welding current	Ampere
$I_0$	Modified Bessel function of the first kind and Zero order.	—
j	Finite difference index in the z-direction	—
k	Thermal conductivity of plate and molten metal	w/ mm.
$k_0$	Modified Bessel function of the second kind and Zero order.	—
L	Thickness of work piece	mm
M	Number of grid in z-direction	—
N	Number of grid in r-direction	—
NDVX	Number of division in X-direction	—
NDVY	Number of division in Y-direction	—
$q_0$	Intensity of line heat source	J/m
$q(r)$	Heat flux on the plane at $z=0$	$J/mm^2$
r	Cylindrical coordinates in line source also cylindrical coordinate.	mm
R	Radial coordinate of limit heat flux effect	mm
t	Time	Sec
T	Temperature in x-y coordinates, also temperature of weldment.	$^{\circ}C$
V	Velocity in axial direction (z)	mm/sec
V	Voltage duty	Volts
W	Width of plate also width of workpiece.	mm
x	The coordinate fixed at the starting point of welding	mm
y	The coordinate of point in the y-direction	mm
z	Cylindrical coordinate	mm

### Greek Symbols

Symbol	Definition	Unit
$\alpha$	Thermal diffusivity of plate	$mm^2/sec$
$\Delta r$	Step size in r-direction	mm
$\Delta X$	Step size in X-direction	mm
$\Delta Y$	Step size in Y-direction	mm
$\Delta z$	Step size in z-direction	mm
$\zeta$	Coordinate for moving heat source	mm
$\theta$	Time in equation (3-1)	Sec
v	Traveling speed of welding	mm/sec
$\varphi$	Angle for cylinder coordinate in line source	—

### Superscript

Symbol	Definition	Unit
/	Advanced time	—
m	Number of alteration	—