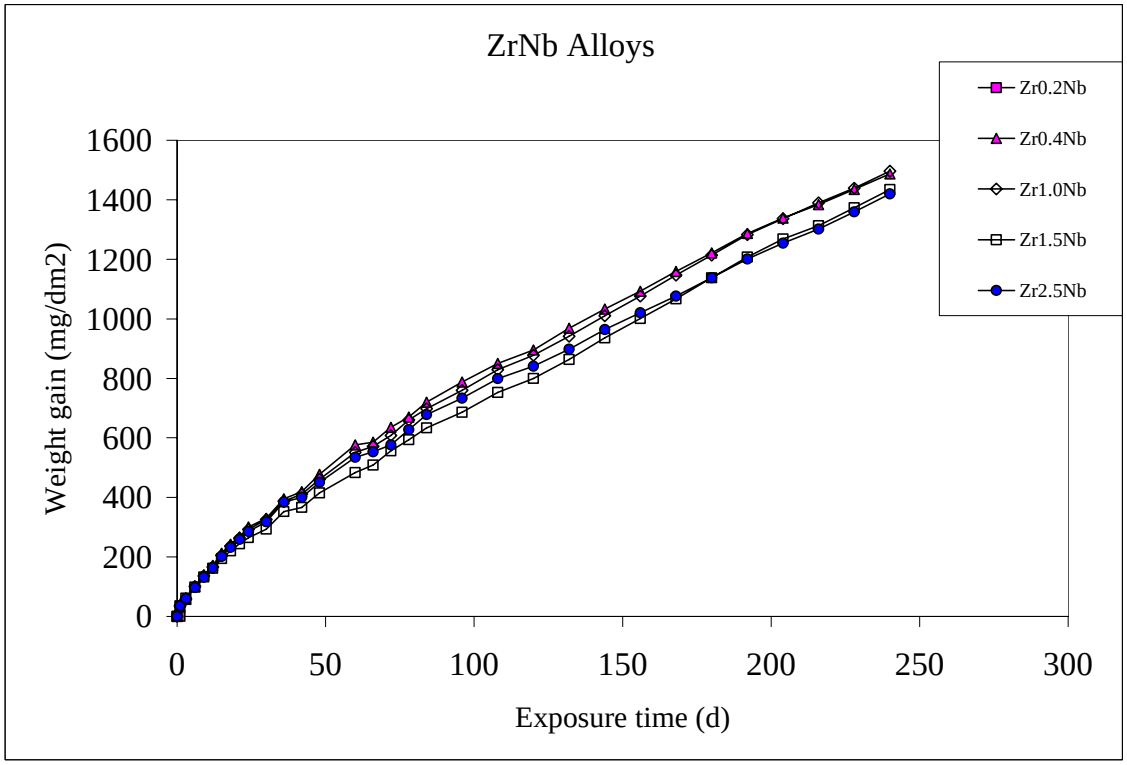
SCW - Static autoclave - KAERI

ZrNb Alloys (SCW, KAERI)

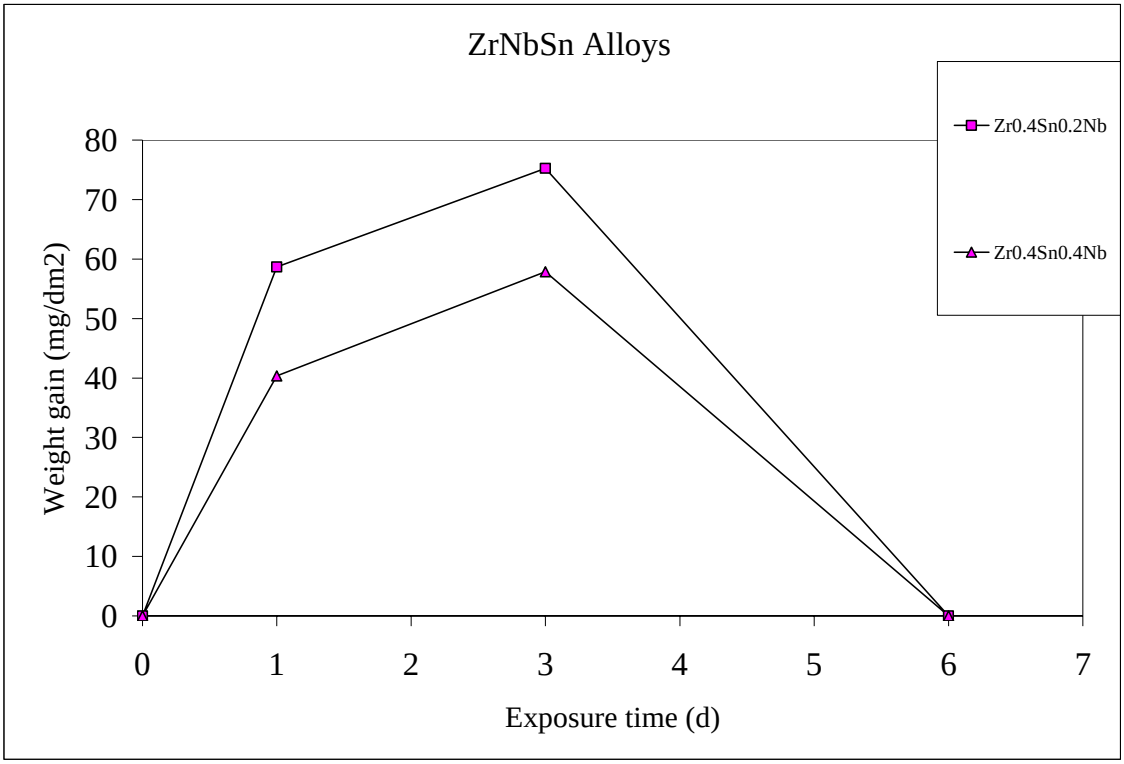


days	0	1	3	6	9	12	15	18	21	24	30
Zr0.2Nb	0	spall									
Zr0.4Nb	0.0	32.4	56.8	99.6	139.5	171.8	212.1	242.8	265.7	300.1	329.7
Zr1.0Nb	0.0	35.0	58.6	100.2	135.9	166.2	205.3	236.5	263.0	292.7	325.9
Zr1.5Nb	0.0	35.5	61.1	98.1	132.1	161.3	193.8	220.0	243.7	264.8	293.4
Zr2.5Nb	0.0	36.0	60.0	97.3	131.8	162.7	201.4	231.9	258.3	285.1	317.6

days	36	42	48	60	66	72	78	84	96	108	120	132
Zr0.2Nb												
Zr0.4Nb	395.0	419.5	477.6	576.6	585.3	635.3	670.2	719.6	788.0	850.0	895.2	968.6
Zr1.0Nb	386.8	410.5	460.9	551.0	571.5	608.5	659.8	698.2	759.7	828.9	877.8	941.2
Zr1.5Nb	352.0	366.4	414.5	483.0	508.4	556.2	593.7	633.4	685.7	752.4	799.6	863.4
Zr2.5Nb	384.0	400.3	450.6	534.7	553.3	576.2	627.7	678.0	733.2	799.0	840.9	898.0

days	144	156	168	180	192	204	216	228	240	
Zr0.2Nb										
Zr0.4Nb	1032.9	1092.6	1159.5	1222.0	1286.7	1338.6	1384.0	1435.4	1486.8	mg/dm2
Zr1.0Nb	1010.1	1075.9	1146.4	1213.9	1283.2	1336.6	1390.2	1439.2	1496.2	mg/dm2
Zr1.5Nb	936.0	1001.2	1066.7	1137.8	1207.6	1268.2	1312.8	1373.2	1434.5	mg/dm2
Zr2.5Nb	964.2	1020.2	1076.3	1137.7	1201.3	1254.6	1301.7	1359.6	1419.9	mg/dm2

ZrNbSn Alloys (SCW, KAERI)

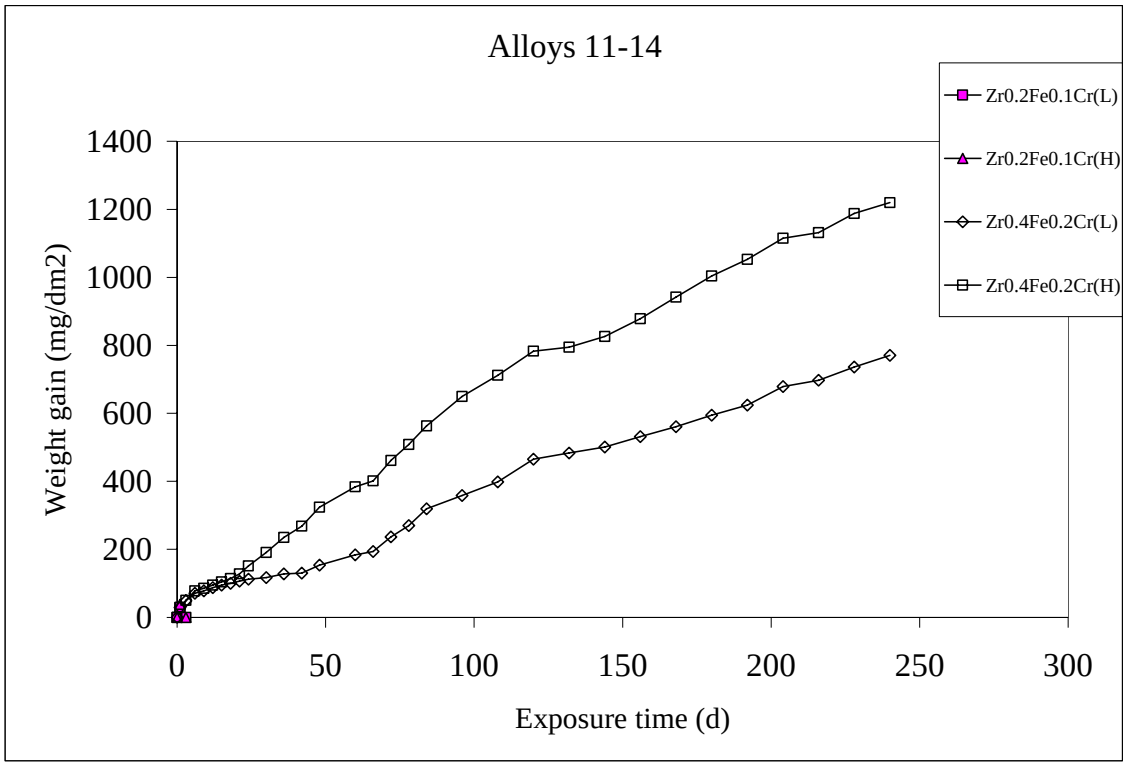


days	0	1	3	6	
Zr0.4Sn0.2Nb	0	58.67437	75.24797	spall	mg/dm2
Zr0.4Sn0.4Nb	0	40.35063	57.87763	spall	mg/dm2

ZrSn Alloys (SCW, KAERI)

days	0	1	
Zr0.2Sn	0	spall	mg/dm2
Zr0.4Sn	0	spall	mg/dm2
Zr0.8Sn	0	spall	mg/dm2
Zr1.2Sn	0	spall	mg/dm2

ZrFeCr Alloys (SCW, KAERI)

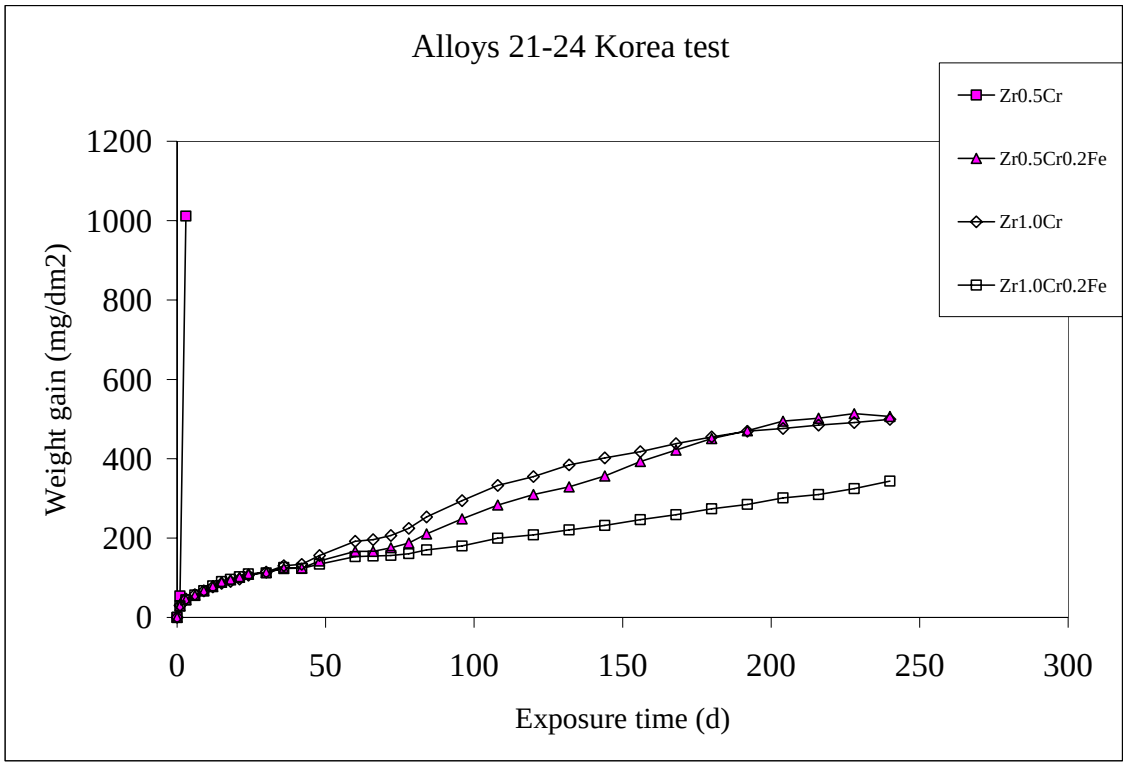


days	0	1	3	6	9	12	15	18	21	24	30	36	42
Zr0.2Fe0.1Cr(L)	0	28.6	spall										
Zr0.2Fe0.1Cr(H)	0	38.4	spall										
Zr0.4Fe0.2Cr(L)	0	28.9	48.6	71.0	78.1	87.1	94.8	100.0	106.4	112.4	117.0	127.9	130.5
Zr0.4Fe0.2Cr(H)	0	29.5	50.0	77.7	85.7	94.8	103.9	113.9	127.9	151.1	190.6	235.3	268.2

days	48	60	66	72	78	84	96	108	120	132	144	156
Zr0.2Fe0.1Cr(L)												
Zr0.2Fe0.1Cr(H)												
Zr0.4Fe0.2Cr(L)	153.8	183.8	193.9	236.6	270.0	319.1	358.4	398.2	465.2	483.1	501.0	531.4
Zr0.4Fe0.2Cr(H)	323.9	384.0	401.6	461.3	508.3	563.2	649.4	711.7	782.7	794.8	826.0	878.4

days	168	180	192	204	216	228	240	
Zr0.2Fe0.1Cr(L)								mg/dm2
Zr0.2Fe0.1Cr(H)								mg/dm2
Zr0.4Fe0.2Cr(L)	560.8	594.4	624.2	678.9	697.5	736.2	770.6	mg/dm2
Zr0.4Fe0.2Cr(H)	941.7	1004.2	1053.0	1115.1	1131.1	1187.8	1219.5	mg/dm2

ZrCrFe Alloys (SCW, KAERI)

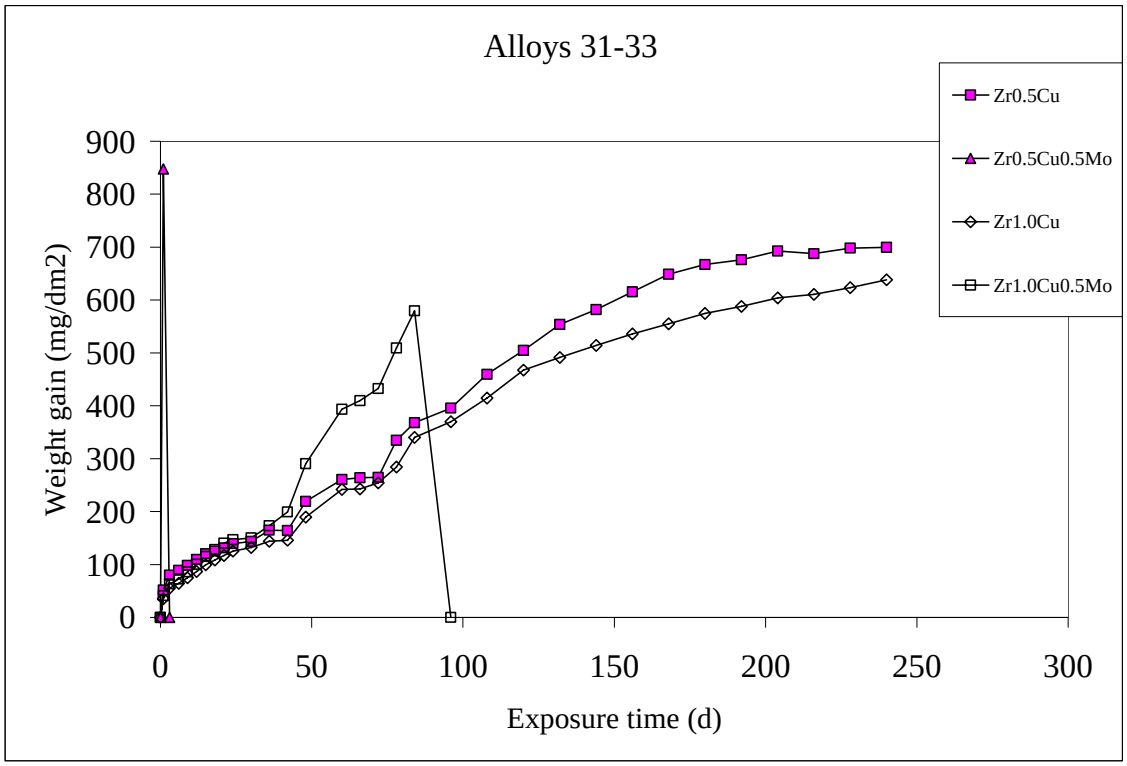


days	0	1	3	6	9	12	15	18	21	24	30	36	42
Zr0.5Cr	0	53.7	1011.4										
Zr0.5Cr0.2Fe	0	28.8	44.3	55.6	66.6	77.9	88.9	94.7	101.4	108.7	113.0	123.3	124.3
Zr1.0Cr	0	30.1	46.4	57.2	67.0	76.6	85.7	90.5	96.7	106.3	114.3	130.0	133.7
Zr1.0Cr0.2Fe	0	28.9	44.6	56.2	67.5	79.3	90.3	95.7	102.0	109.5	112.1	125.4	123.1

days	48	60	66	72	78	84	96	108	120	132	144	156	168
Zr0.5Cr													
Zr0.5Cr0.2Fe	142.1	166.4	166.7	175.3	187.3	210.6	248.0	282.9	309.5	328.8	356.5	392.9	421.8
Zr1.0Cr	155.9	191.8	196.1	206.3	224.2	253.5	294.3	332.6	354.7	384.2	401.9	417.7	437.7
Zr1.0Cr0.2Fe	133.9	153.3	154.5	156.3	160.7	170.0	180.2	199.3	208.0	220.2	231.8	246.2	259.0

days	180	192	204	216	228	240	
Zr0.5Cr							mg/dm2
Zr0.5Cr0.2Fe	450.8	470.4	494.6	501.9	513.5	506.7	mg/dm2
Zr1.0Cr	454.9	469.0	475.9	484.4	491.1	499.0	mg/dm2
Zr1.0Cr0.2Fe	273.5	284.8	301.3	309.6	324.5	343.6	mg/dm2

ZrCuMo Alloys (SCW, KAERI)

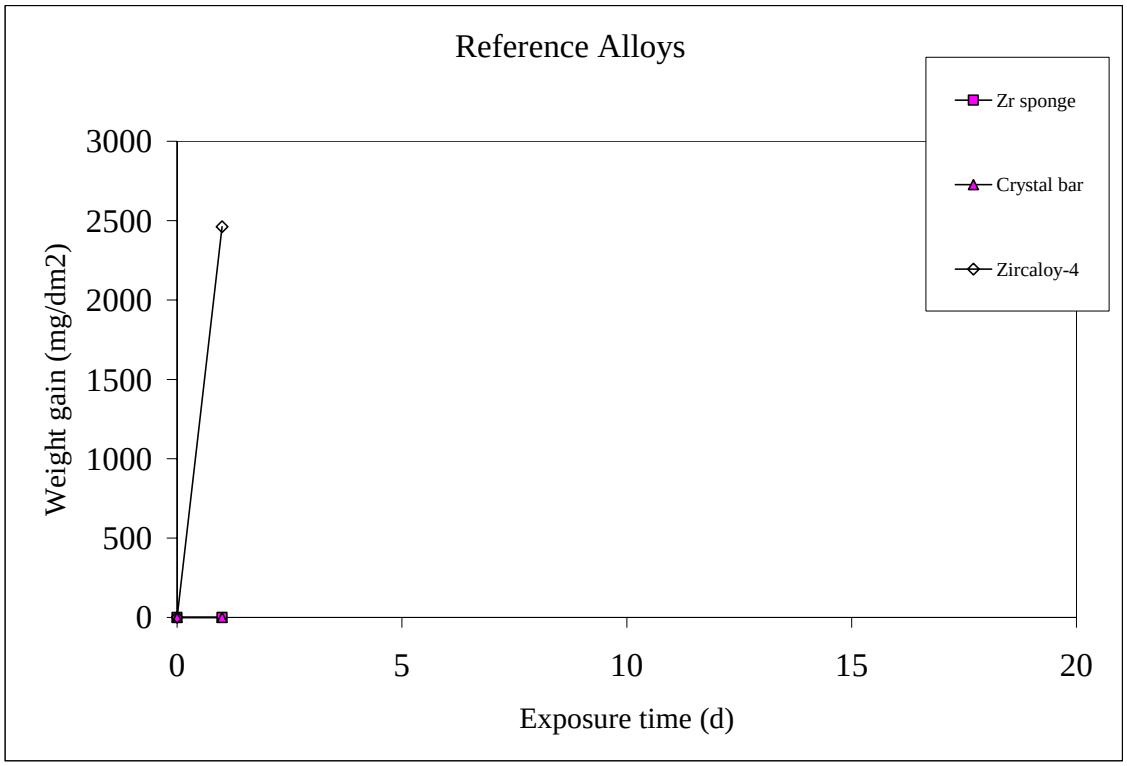


days	0	1	3	6	9	12	15	18	21	24	30	36
Zr0.5Cu	0	51.6	79.6	89.0	98.4	109.7	120.4	125.4	131.4	139.6	143.5	164.9
Zr0.5Cu0.5Mo	0	847.8	spall									
Zr1.0Cu	0	35.2	55.2	64.2	74.9	86.7	99.6	108.4	117.0	125.2	131.8	143.9
Zr1.0Cu0.5Mo	0	41.3	63.1	72.5	86.1	100.2	115.2	128.1	140.1	147.1	150.3	173.0

days	42	48	60	66	72	78	84	96	108	120	132
Zr0.5Cu	164.1	219.0	260.7	263.8	264.6	334.5	367.8	395.6	459.5	504.7	553.8
Zr0.5Cu0.5Mo											
Zr1.0Cu	145.8	189.4	241.8	242.8	254.3	284.2	340.3	369.7	414.6	467.5	491.3
Zr1.0Cu0.5Mo	199.2	290.4	393.3	409.8	432.6	509.3	579.5	spall			

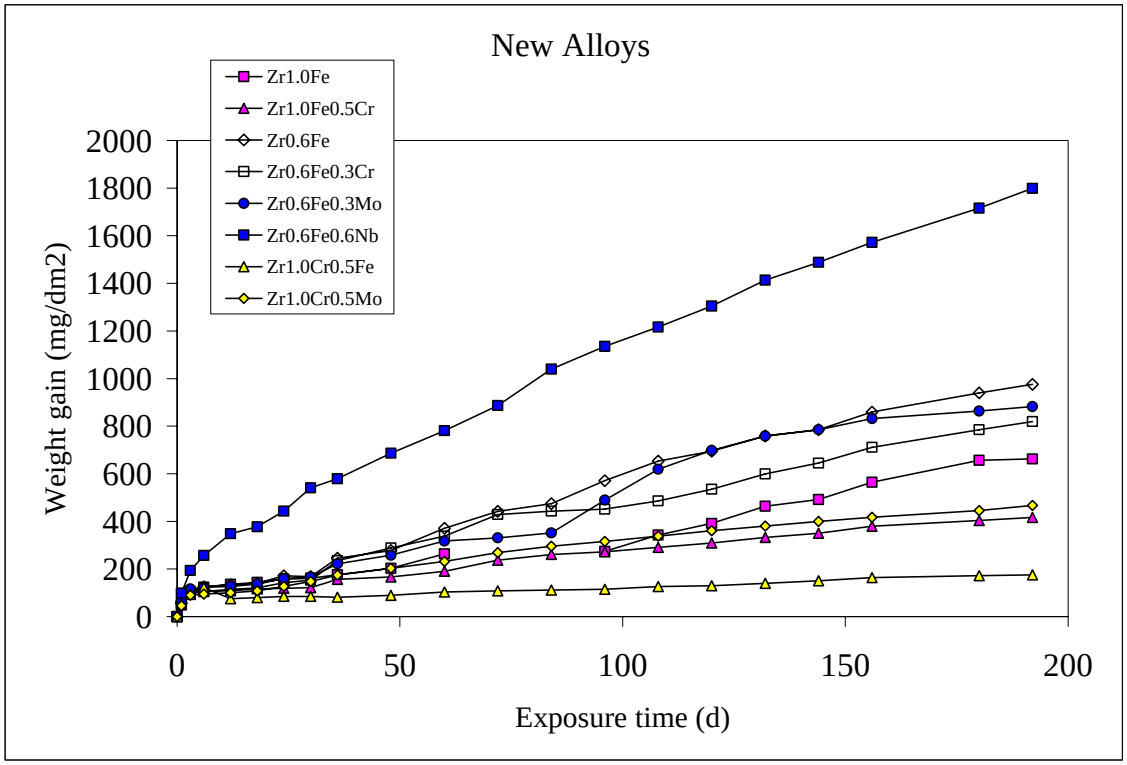
days	144	156	168	180	192	204	216	228	240	
Zr0.5Cu	581.6	615.4	648.7	667.1	675.9	692.6	687.4	698.1	699.8	mg/dm2
Zr0.5Cu0.5Mo										mg/dm2
Zr1.0Cu	514.3	536.0	555.0	574.9	587.8	603.9	610.7	623.3	638.3	mg/dm2
Zr1.0Cu0.5Mo										mg/dm2

Reference Alloys (SCW, KAERI)



days	0	1	
Zr sponge	0	spall	mg/dm2
Crystal bar	0	spall	mg/dm2
Zircaloy-4	0	2461.7	mg/dm2

New Alloys (SCW, KAERI)



days	0	1	3	6	12	18	24	30	36	48	60	72	84
Zr1.0Fe	0	56.4	106.4	123.8	135.2	143.4	157.1	161.6	176.0	202.6	263.3		
Zr1.0Fe0.5Cr	0	49.6	96.1	105.9	109.0	116.1	118.8	121.2	156.4	166.0	190.7	237.1	260.8
Zr0.6Fe	0	56.2	106.8	124.4	133.9	140.8	171.3	168.3	245.3	277.6	370.7	442.1	474.3
Zr0.6Fe0.3Cr	0	49.1	100.0	105.7	114.0	120.7	142.1	153.2	234.8	288.0	338.3	428.9	443.3
Zr0.6Fe0.3Mo	0	61.9	116.1	122.9	127.0	136.3	159.5	166.1	222.2	257.8	317.3	330.3	351.7
Zr0.6Fe0.6Nb	0	98.7	193.4	256.9	347.8	377.1	443.1	540.7	579.1	686.0	781.2	886.8	1039.3
Zr1.0Cr0.5Fe	0	51.3	93.4	122.0	74.8	80.1	85.0	85.0	81.3	88.9	102.9	108.2	111.0
Zr1.0Cr0.5Mo	0	45.8	89.9	94.8	99.5	108.3	127.1	147.6	174.9	202.7	232.1	268.3	295.9

days	96	108	120	132	144	156	180	192		
Zr1.0Fe	274.0	342.1	391.6	463.9	492.3	564.0	656.5	662.3		mg/dm2
Zr1.0Fe0.5Cr	271.5	290.7	309.0	332.7	349.9	379.8	404.1	416.2		mg/dm2
Zr0.6Fe	570.6	652.7	694.6	758.3	784.9	859.5	939.4	975.5		mg/dm2
Zr0.6Fe0.3Cr	451.2	485.9	535.5	598.9	644.4	711.2	785.5	819.2		mg/dm2
Zr0.6Fe0.3Mo	489.4	619.4	698.1	758.7	784.9	831.4	863.7	882.8		mg/dm2
Zr0.6Fe0.6Nb	1135.0	1216.2	1304.5	1413.5	1488.1	1572.0	1715.9	1799.2		mg/dm2
Zr1.0Cr0.5Fe	115.0	125.9	129.4	140.0	150.0	164.1	171.7	175.7	(Partially spalled)	mg/dm2
Zr1.0Cr0.5Mo	315.6	338.0	360.9	380.9	399.4	417.3	445.4	466.9		mg/dm2

SCW - Dynamic Autoclave - UM

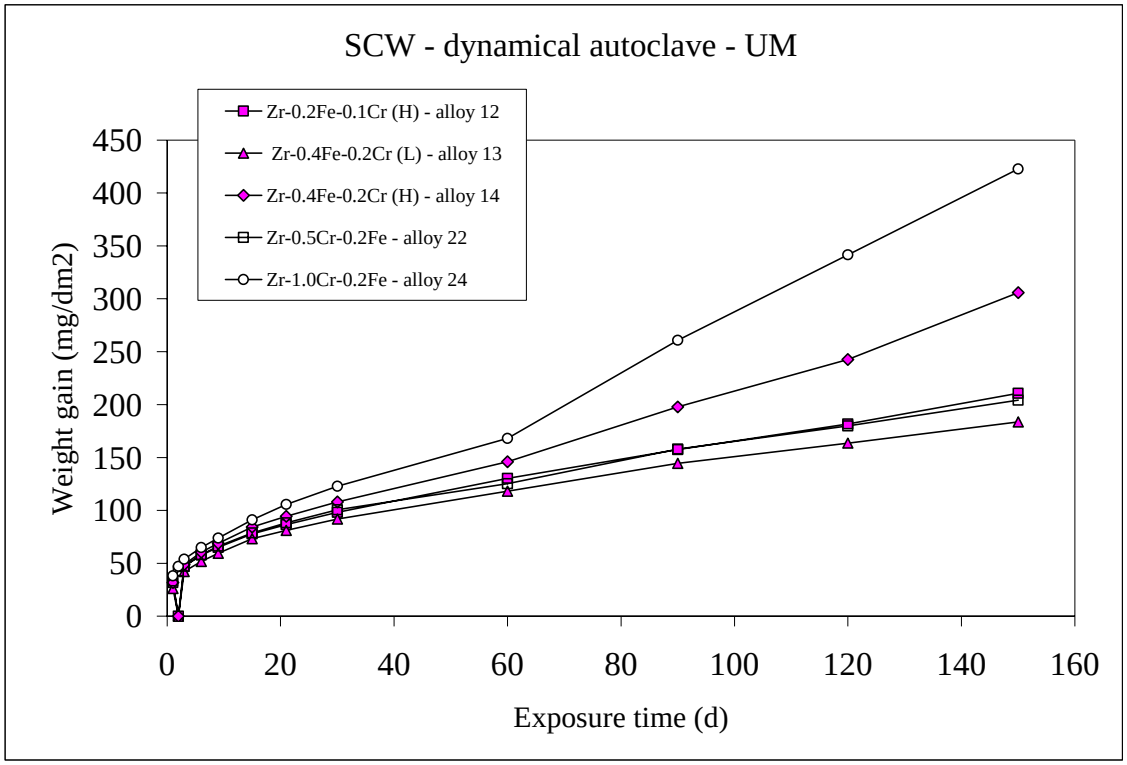
Experimental alloys tested in this study.

Alloy system	Alloys and composition (wt%)
Zr-Fe-Cr	Zr-0.2Fe-0.1Cr
	Zr-0.4Fe-0.2Cr
Zr-Cr-Fe	Zr-0.5Cr
	Zr-0.5Cr-0.2Fe
	Zr-1.0Cr
	Zr-1.0Cr-0.2Fe
Zr-Cu-Mo	Zr-0.5Cu
	Zr-0.5Cu-0.5Mo
	Zr-1.0Cu
	Zr-1.0Cu-0.5Mo

Average weight gain (for two samples) of tested alloys after exposure for 24 hours.

Alloy system	Alloy	Ave. weight gain, 24 hr. (mg/dm^2)
Zr-Fe-Cr	Zr-0.2Fe-0.1Cr (720°)	27.9
	Zr-0.4Fe-0.2Cr (580°)	25.5
	Zr-0.4Fe-0.2Cr (720°)	29.5
Zr-Cr-Fe	Zr-0.5Cr	4282.2
	Zr-0.5Cr-0.2Fe	32.0
	Zr-1.0Cr-0.2Fe	38.0
Zr-Cu-Mo	Zr-0.5Cu	3966.5
	Zr-0.5Cu-0.5Mo	-1669.2 (spalling)
	Zr-1.0Cu	550.3
	Zr-1.0Cu-0.5Mo	576
Reference	Zircaloy-4	disintegrated

ZrFeCr and ZrCrFe Alloys (SCR, UM)



Alloy	1	2	3	6	9	15	21	30	60	90	120	150	days
Zr-0.2Fe-0.1Cr (H) - alloy 12	31.7	0	46.9	57.7	65	77.8	86.5	98.1	130.3	157.4	181.8	210.7	mg/dm2
Zr-0.4Fe-0.2Cr (L) - alloy 13	26.2	0	42.3	51.7	59.4	73.2	81.1	91.8	118.1	144.6	163.6	183.5	mg/dm2
Zr-0.4Fe-0.2Cr (H) - alloy 14	31.7	0	48.8	60.6	68.8	84.4	94.4	108	146.1	197.8	242.7	305.8	mg/dm2
Zr-0.5Cr-0.2Fe - alloy 22	33.2	42.9	47.1	58.1	66.1	78.8	88.2	100.5	125.2	157.9	179.8	204.1	mg/dm2
Zr-1.0Cr-0.2Fe - alloy 24	38.1	47.2	53.8	64.8	73.8	91.1	105.6	122.9	168.1	260.8	341.6	422.7	mg/dm2