

Supplementary Material for **A Framework for Globally Optimizing Mixed-Integer Signomial Programs**

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1 Test Suite Definition

Table S1: Belgian Chocolate Problems [88, 89]

Problem Name	# Variables			# Constraints	# Nonlinear Terms	Best Known Sol'n
	Contin	Binary	Integer			
bcp5	85	6	0	104	92	0.9521
bcp6	112	7	0	135	148	0.9749
bcp7	127	8	0	154	183	0.9749
bcp8	160	9	0	191	261	0.9848

Table S2: Cascading Tanks Problems: MINLP and MPCC Formulations [90]

Problem Name	# Variables			# Constraints	# Nonlinear Terms
	Contin	Binary	Integer		
Cascade_MINLP_1T_20FE	461	40	0	518	514
Cascade_MINLP_1T_40FE	921	80	0	1038	1034
Cascade_MINLP_3T_20FE	1181	40	0	1558	1748
Cascade_MINLP_3T_40FE	2361	80	0	3118	3508
Cascade_MPCC_1T_20FE	662	0	0	439	714
Cascade_MPCC_1T_40FE	1322	0	0	879	1434
Cascade_MPCC_3T_20FE	1622	0	0	1239	2188
Cascade_MPCC_3T_40FE	3242	0	0	2479	4388

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Table S3: Cyclic Scheduling and Control Problems [91]

Problem Name	# Variables			# Constraints	# Nonlinear Terms	Best Known Sol'n
	Contin	Binary	Integer			
caso-1-sc-v2	1507	50	0	1266	3116	7.8885656e+03

Table S4: Distillation Separation Sequence Problems [92, 93, 94, 95]

Problem Name	# Variables			# Constraints	# Nonlinear Terms	Best Known Sol'n
	Contin	Binary	Integer			
Conventional	622	20	0	1129	1420	4.8908e+02

Table S5: Heat Exchanger Networks [96]

Problem Name	# Variables			# Constraints	# Nonlinear Terms	Best Known Sol'n
	Contin	Binary	Integer			
Escobar_HEN1	45	12	0	65	32	1.549973e+05
Escobar_HEN2	61	16	0	91	42	6.349793e+05
Escobar_HEN3	201	60	0	251	170	6.493723e+04

Table S6: Metabolic Networks in Biotechnology [80, 81]

Problem Name	# Variables			# Constraints	# Nonlinear Terms	Best Known Sol'n
	Contin	Binary	Integer			
GMA.ethanol.model.BigM	14	24	0	73	47	1.5759e+02
GMA.ethanol.model.CH	38	24	0	81	47	1.5759e+02

Table S7: Designing Multi-Product Batch Plants [98, 99, 100]

Problem Name	# Variables			# Constraints	# Nonlinear Terms	Best Known Sol'n
	Contin	Binary	Integer			
batch_plant_nonconvex1	23	12	0	68	82	2.85506e+05
batch_plant_nonconvex2	41	36	0	206	232	2.68703e+06

Table S8: Periodic Scheduling of Continuous Multi-Product Plants [101, 102]

Problem Name	# Variables			# Constraints	# Nonlinear Terms	Best Known Sol'n
	Contin	Binary	Integer			
MTG_EX1	77	48	0	196	95	3.52446e+02
MTG_EX1a	101	93	0	257	95	3.91613e+02
MTG_EX1b	101	93	0	257	95	4.50548e+02
MTG_EX1c	125	120	0	319	95	6.83971e+02
MTG_EX2	118	112	0	307	126	7.09917e+03
MTG_EX5	113	78	0	309	164	5.92420e+03
MTG_EX6	174	176	0	481	218	5.31276e+03
STG_EX1	217	198	0	262	175	3.55087e+02
STG_EX1a	208	216	0	250	127	3.90966e+02
STG_EX1b	233	243	0	280	143	4.68056e+02
STG_EX1c	225	252	0	270	111	7.08440e+02
STG_EX5	235	216	0	299	127	5.78904e+03
STG_EX6	310	384	0	388	166	5.16612e+03

Table S9: Supply Chain Design [103, 104]

Problem Name	# Variables			# Constraints	# Nonlinear Terms	Best Known Sol'n
	Contin	Binary	Integer			
you_scd_1	7	21	0	28	27	2.26026e+03
you_scd_2	25	3	0	31	6	2.26026e+03

Table S10: Unit Commitment [108, 109]

Problem Name	# Variables			# Constraints	# Nonlinear Terms	Best Known Sol'n
	Contin	Binary	Integer			
zondervan_UC_convex	241	720	0	5330	240	5.78176e+05
zondervan_UC_nonconvex	241	720	0	5330	480	5.78176e+05

Table S11: Water Distribution Network [110, 111]; Formulation of S. Vigerske

Problem Name	# Variables			# Constraints	# Nonlinear Terms	Best Known Sol'n
	Contin	Binary	Integer			
shamir	40	120	0	87	40	4.19000e+05
hanoi	169	238	0	372	170	6.10962e+06
blacksburg	172	525	0	381	175	1.16945e+05
foss_iron	270	812	0	617	290	1.75922e+05
foss_poly_0	270	464	0	617	290	6.75592e+07
foss_poly_1	270	1334	0	617	290	2.78506e+04
pescara	468	1386	0	1059	495	1.82026e+06
modena	1541	4438	0	3439	1585	2.57659e+06

Table S12: Water Treatment Network [112, 113, 114, 115]

Problem Name	# Variables			# Constraints	# Nonlinear Terms	Best Known Sol'n
	Contin	Binary	Integer			
ahmetovic_Ex1.NoEps	55	20	0	84	114	6.06760e+05
ahmetovic_Ex1.WithEps	55	20	0	84	114	6.06760e+05
ahmetovic_Ex2.NoEps	161	72	0	250	525	1.06273e+06
ahmetovic_Ex2.WithEps	161	72	0	250	525	1.06273e+06
ruiz_concbased	356	5	0	320	525	3.48340e+05
ruiz_flowbased	416	5	0	380	305	3.48340e+05

Table S13: Three-Echelon Supply Chain [105, 106, 107]

Problem Name	# Variables			# Constraints	# Nonlinear Terms
	Contin	Binary	Integer		
ngw-r1-22020	981	460	0	1841	40
ngw-r1-236	67	27	0	115	9
ngw-r1-3510	161	70	0	281	15
ngw-r1-53050	3471	1680	0	6581	80
ngw-you-22020	2481	460	0	5301	40
ngw-you-236	124	27	0	256	9
ngw-you-33050	13641	1680	0	33191	80
ngw-you-3510	376	70	0	836	15

Table S14: GLOBALLib Case Studies [79, 116]

Problem Name	# Variables			# Constraints	# Nonlinear Terms
	Contin	Binary	Integer		
alkylation	11	0	0	12	14
alkyl	15	0	0	8	19
arki0003	2283	0	0	2583	4080
arki0005	2371	0	0	5153	12768
arki0006	2371	0	0	5153	12768
camcge	280	0	0	243	850
chain100	203	0	0	102	303
chain200	403	0	0	202	603
chain400	803	0	0	402	1203
chain50	103	0	0	52	153
chakra	63	0	0	42	41
chance	5	0	0	4	4
chenery	44	0	0	39	56
elec100	301	0	0	101	600
elec200	601	0	0	201	1200

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Table S14 (GLOBALLib) continued

Problem Name	# Variables			# Constraints	# Nonlinear Terms
	Contin	Binary	Integer		
elec25	76	0	0	26	150
elec50	151	0	0	51	300
ex14.1.1	4	0	0	5	8
ex14.1.2	7	0	0	10	26
ex14.1.5	7	0	0	7	10
ex14.2.4	6	0	0	8	24
ex14.2.5	5	0	0	6	12
ex4.1.1	2	0	0	1	1
ex4.1.2	2	0	0	1	1
ex4.1.3	2	0	0	1	1
ex4.1.4	2	0	0	1	1
ex4.1.5	3	0	0	1	2
ex4.1.6	2	0	0	1	1
ex4.1.7	2	0	0	1	1
ex4.1.8	3	0	0	2	2
ex4.1.9	3	0	0	3	2
ex5.4.3	17	0	0	14	18
ex5.4.4	28	0	0	20	33
ex7.2.1	8	0	0	15	35
ex7.2.2	7	0	0	6	10
ex7.2.3	9	0	0	7	10
ex7.2.4	9	0	0	5	14
ex7.3.1	5	0	0	8	3
ex7.3.2	5	0	0	8	3
ex7.3.4	13	0	0	18	23
ex7.3.5	14	0	0	16	25
ex8.1.3	3	0	0	1	2
ex8.1.4	3	0	0	1	2
ex8.1.5	3	0	0	1	2
ex8.1.6	3	0	0	1	2
ex8.1.7	6	0	0	6	13
ex8.3.10	142	0	0	109	567
ex8.3.6	111	0	0	77	425
ex8.3.7	127	0	0	93	537
ex8.4.2	25	0	0	11	60
ex8.4.3	53	0	0	26	100
ex8.4.5	16	0	0	12	55
ex8.6.1	76	0	0	46	315
gasoil100	2604	0	0	2599	3002
gasoil200	5204	0	0	5199	5802
gasoil400	10404	0	0	10399	11402
gasoil50	1304	0	0	1299	1602
gsg.0001	78	0	0	112	44
harker	21	0	0	8	20

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Table S14 (GLOBALLib) continued

Problem Name	# Variables			# Constraints	# Nonlinear Terms
	Contin	Binary	Integer		
hhfair	30	0	0	26	21
korcge	96	0	0	78	200
mathopt1	3	0	0	3	4
mathopt2	3	0	0	5	4
methanol100	3006	0	0	2998	5895
methanol200	6006	0	0	5998	11595
methanol400	12006	0	0	11998	22995
methanol50	1506	0	0	1498	3033
mhw4d	6	0	0	4	10
minlphi	65	0	0	80	36
minsurf100	5305	0	0	1	5304
minsurf25	1405	0	0	1	1404
minsurf50	2705	0	0	1	2704
minsurf75	4005	0	0	1	4004
otpop	104	0	0	77	83
pindyck	117	0	0	97	80
pollut	43	0	0	9	40
prob07	15	0	0	36	63
prob09	3	0	0	1	2
process	11	0	0	8	11
rbrock	3	0	0	1	2
sample	5	0	0	3	8
ship	11	0	0	17	31
srcpm	40	0	0	28	5

Table S15: MINLPLib Case Studies [117, 79]

Problem Name	# Variables			# Constraints	# Nonlinear Terms
	Contin	Binary	Integer		
cecil_13	661	180	0	899	360
eniplac	118	24	0	190	48
ex1221	3	3	0	6	2
ex1225	3	6	0	11	2
ex1226	3	3	0	6	2
ex1233	41	12	0	65	28
ex1243	53	16	0	97	36
ex1244	73	23	0	130	52
ex1252a	16	3	6	35	36
ex1252	25	15	0	44	36
fac1	17	6	0	19	16
fac2	55	12	0	34	54
fo7_2	73	42	0	212	14
fo7_ar2_1	71	0	42	270	14

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Table S15 (MINLPLib) continued

Problem Name	# Variables			# Constraints	# Nonlinear Terms
	Contin	Binary	Integer		
fo7_ar25.1	71	0	42	270	14
fo7_ar3.1	71	0	42	270	14
fo7_ar4.1	71	0	42	270	14
fo7_ar5.1	71	0	42	270	14
fo7	73	42	0	212	14
fo8_ar2.1	89	0	56	348	16
fo8_ar25.1	89	0	56	348	16
fo8_ar3.1	89	0	56	348	16
fo8_ar4.1	89	0	56	348	16
fo8_ar5.1	89	0	56	348	16
fo8	91	56	0	274	16
fo9_ar2.1	109	0	72	436	18
fo9_ar25.1	109	0	72	436	18
fo9_ar3.1	109	0	72	436	18
fo9_ar4.1	109	0	72	436	18
fo9_ar5.1	109	0	72	436	18
fo9	111	72	0	344	18
gasnet	81	10	0	70	130
gastrans	86	21	0	150	45
gear2	5	24	0	5	4
gear3	5	0	4	5	4
gear4	3	0	4	2	4
gear	1	0	4	1	4
hmittelman	1	16	0	8	122
johnall	5	190	0	193	573
m3	21	6	0	44	6
m6	57	30	0	158	12
m7_ar2.1	71	0	42	270	14
m7_ar25.1	71	0	42	270	14
m7_ar3.1	71	0	42	270	14
m7_ar4.1	71	0	42	270	14
m7_ar5.1	71	0	42	270	14
m7	73	42	0	212	14
minlphix	65	20	0	93	40
no7_ar2.1	71	0	42	270	14
no7_ar25.1	71	0	42	270	14
no7_ar3.1	71	0	42	270	14
no7_ar4.1	71	0	42	270	14
no7_ar5.1	71	0	42	270	14
nvs01	2	0	2	4	7
nvs02	4	0	5	4	16
nvs04	1	0	2	1	2
nvs05	7	0	2	10	24
nvs06	1	0	2	1	2

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Table S15 (MINLPLib) continued

Problem Name	# Variables			# Constraints	# Nonlinear Terms
	Contin	Binary	Integer		
nvs07	1	0	3	3	3
nvs08	2	0	2	4	7
nvs16	1	0	2	1	2
nvs20	12	0	5	9	16
nvs21	2	0	2	3	7
nvs22	5	0	4	10	24
o7_2	73	42	0	212	14
o7_ar2.1	71	0	42	270	14
o7_ar25.1	71	0	42	270	14
o7_ar3.1	71	0	42	270	14
o7_ar4.1	71	0	42	270	14
o7_ar5.1	71	0	42	270	14
o7	73	42	0	212	14
o8_ar4.1	89	0	56	348	16
o9_ar4.1	109	0	72	436	18
ortez	70	18	0	75	54
parallel	181	25	0	116	155
pump	16	3	6	35	36
risk2b	450	14	0	581	3
risk2bpb	450	14	0	581	3
spring	6	11	1	9	14
st_e15	3	3	0	6	2
st_e35	26	7	0	40	16
stockcycle	49	432	0	98	48
synheat	45	12	0	65	28
tls12	145	656	12	385	288
tls2	5	31	2	25	8
tls4	17	85	4	65	32
tls5	26	131	5	91	50
tls6	37	173	6	121	72
tls7	50	289	7	155	98
waterx	57	14	0	55	60

Table S16: MacMOOPLib Test Set

Problem Name	# Variables			# Constraints	# Nonlinear Terms
	Contin	Binary	Integer		
leyffer_ex001	6	0	0	4	8
leyffer_ex002	6	0	0	3	2
leyffer_ex003	3	0	0	3	5
leyffer_ex005	3	0	0	1	2

Table S17: AMPL Book Lib Test Set [118]

Problem Name	# Variables			# Constraints	# Nonlinear Terms
	Contin	Binary	Integer		
nltrans	22	0	0	11	21
steelp11	29	0	0	13	4
steelp12	29	0	0	13	4
steelp13	29	0	0	13	12
steelp14	29	0	0	13	4
steelp15	29	0	0	13	12
transpl1	22	0	0	11	21

Table S18: Bonmin Test Set [119, 120]

Problem Name	# Variables			# Constraints	# Nonlinear Terms
	Contin	Binary	Integer		
FLay02H	43	4	0	52	2
FLay02M	11	4	0	12	2
FLay03H	111	12	0	145	3
FLay03M	15	12	0	25	3
FLay04H	211	24	0	283	4
FLay04M	19	24	0	43	4
FLay05H	343	40	0	466	5
FLay05M	23	40	0	66	5
FLay06H	507	60	0	694	6
FLay06M	27	60	0	94	6

Table S19: Literature Test Problems [121]

Problem Name	# Variables			# Constraints	# Nonlinear Terms
	Contin	Binary	Integer		
ytz_1	4	0	0	2	6
ytz_2	4	0	0	2	6
ytz_3	6	0	0	2	9
ytz_4	6	0	0	2	10
ytz_5	11	0	0	3	19

2 Testing Results

Table S20: 60 min.lp.org Test Cases – Commercial Solvers

Problem Name	MESO Framework				BARON 12.3.3				LINDO 8.0			
	Time	Gap	LB	UB	Time	Gap	LB	UB	Time	Gap	LB	UB
Conventional	0	–	–	–	7200	9.53e+01	2.283e+01	4.825e+02	60	1.00e-04	4.825e+02	4.825e+02
Escobar.HEN1	7200	2.30e+01	1.193e+05	–	281	1.00e-04	1.350e+05	1.500e+05	2070	3.22e+00	1.500e+05	1.500e+05
Escobar.HEN2	7200	1.43e-01	8.322e+05	8.332e+05	–	–	–	–	1679	1.21e-01	6.32e+05	6.350e+05
Escobar.HEN3	2691	1.00e-04	6.420e+04	6.420e+04	7200	1.57e+01	5.408e+04	6.414e+04	442	2.66e+01	4.711e+04	6.420e+04
Gda.Ethanol.Model.Ich	1	1.00e-04	-1.576e+02	-1.576e+02	0	1.00e-04	-1.576e+02	-1.576e+02	0	1.00e-04	-1.576e+02	-1.576e+02
MITC.Ex1	7200	4.59e-01	-3.523e+02	-3.523e+02	1130	1.00e-04	-5.521e+02	-5.521e+02	1383	1.00e-04	-5.521e+02	-5.521e+02
MITC.Ex1a	7200	1.63e-01	-4.553e+02	-4.553e+02	7200	1.00e-04	-6.053e+02	-6.053e+02	484	1.00e-02	-8.229e+02	-3.916e+02
MITC.Ex1b	7200	1.69e-02	-1.213e+03	-4.950e+02	7200	1.80e+03	-9.667e+02	-5.085e+01	242	5.89e+02	-3.109e+03	-4.950e+02
MITC.Ex1c	7200	1.68e+02	-1.702e+03	-6.674e+02	7200	2.63e+00	-7.151e+03	-6.968e+03	238	6.23e+02	-4.946e+03	-6.840e+02
MITC.Ex2	13	1.00e-04	-7.081e+03	-7.081e+03	7200	2.63e+00	-7.151e+03	-6.968e+03	673	9.11e+00	-7.746e+03	-7.099e+03
MITC.Ex2a	7200	1.30e+00	-6.002e+03	-5.925e+03	–	–	–	–	1105	1.78e+01	-6.209e+03	-5.922e+03
MITC.Ex2b	7200	2.81e+00	-5.419e+03	-5.271e+03	7200	–	-5.481e+03	–	693	–	–	0.000e+00
MITC.Ex2c	7200	5.83e+02	-2.278e+03	-3.335e+02	7200	–	-1.751e+03	–	251	3.08e+04	-8.682e+03	2.828e+01
MITC.Ex1a	7200	2.01e+02	-1.1778e+03	-3.910e+02	7200	1.41e+03	-1.640e+03	-1.089e+02	687	1.94e+04	-7.999e+04	0.103e+02
MITC.Ex1b	7200	1.65e+02	-1.239e+03	-4.676e+02	7200	–	-1.409e+03	–	87	–	–	0.000e+00
MITC.Ex1c	7200	1.72e+02	-1.901e+03	-6.984e+02	7200	–	-2.881e+04	–	1113	2.08e+07	-2.081e+05	0.000e+00
MITC.Ex5	7200	5.53e+00	-6.108e+03	-5.166e+03	7200	–	-3.814e+04	–	805	2.20e+00	5.934e+05	6.068e+05
MITC.Ex6	383	1.00e-04	-5.166e+03	-5.166e+03	254	1.00e-04	6.068e+05	6.068e+05	1251	1.67e+00	1.050e+06	1.067e+06
ahmetovic.Ex1.NoGps	2	1.00e-04	6.068e+05	6.068e+05	7	1.00e-04	6.068e+05	6.068e+05	1154	1.08e+00	1.051e+06	1.063e+06
ahmetovic.Ex1.WithGps	1	1.00e-04	6.068e+05	6.068e+05	7	1.00e-04	6.068e+05	6.068e+05	40	1.00e-04	2.853e+05	2.853e+05
ahmetovic.Ex2.NoGps	7200	7.37e+01	1.051e+06	4.003e+06	7200	2.96e+00	1.049e+06	1.084e+06	1646	4.52e+00	9.949e-01	-9.519e-01
ahmetovic.Ex2.WithGps	7200	1.03e+00	1.052e+06	1.063e+06	7200	–	–	–	777	3.55e+00	-9.970e-01	-9.628e-01
batch.plant.nonconvex1	13	1.04e-04	2.855e+05	2.855e+05	–	–	–	–	3013	1.92e+00	-9.135e-01	-9.630e-01
batch.plant.nonconvex2	13	1.94e-04	2.687e+06	2.687e+06	–	–	–	–	7200	3.98e+00	-9.617e-01	-9.617e-01
bcp5	7200	1.20e+00	-9.633e-01	-9.519e-01	7200	3.36e+00	-9.839e-01	-9.519e-01	1646	4.52e+00	9.949e-01	-9.519e-01
bcp7	7200	4.40e+00	-9.994e-01	-9.573e-01	7200	2.38e+00	-9.873e-01	-9.627e-01	777	3.55e+00	-9.970e-01	-9.628e-01
bcp8	7200	5.93e-01	-9.684e-01	-9.630e-01	7200	3.98e+00	-9.999e-01	-9.617e-01	3013	1.92e+00	-9.135e-01	-9.630e-01
caseo-1-sec-v2	1469	1.06e+00	9.798e-01	9.798e-01	7200	–	-9.413e+03	–	7200	1.000e+00	-1.000e+00	-1.000e+00
kuiz.zombased	7200	2.98e+00	3.1767e+12	3.1767e+12	7200	1.00e-04	3.483e+05	3.483e+05	753	7.96e+14	3.725e+12	0.000e+00
kuiz.zombased	7200	3.57e-01	3.471e+05	3.483e+05	825	1.00e-04	3.483e+05	3.483e+05	753	7.96e+14	3.725e+12	0.000e+00
youanpoly.chair.design.1	7200	1.00e-04	2.260e+03	2.260e+03	4	1.00e-04	2.260e+03	2.260e+03	2	1.00e-04	2.260e+03	2.260e+03
youanpoly.chair.design.2	0	–	–	–	–	–	–	–	–	–	–	–
zende.ran.jic.nonconv	7200	2.98e-04	5.782e+05	5.782e+05	7200	3.30e-01	5.767e+05	5.782e+05	58	1.00e-04	5.782e+05	5.782e+05
zende.ran.jic.nonconv	7200	7.25e-03	5.781e+05	5.782e+05	7200	1.33e+01	5.059e+05	5.832e+05	1111	1.00e-04	1.899e+05	0.000e+00
Casead.ngfTanka.MINLP.1Tank.20FE	7200	7.43e+00	8.483e+00	9.163e+00	7200	4.12e+04	9.163e+00	9.163e+00	7200	2.06e+00	8.975e+00	9.163e+00
Casead.ngfTanka.MINLP.1Tank.40FE	7200	3.76e+01	7.895e+00	1.227e+01	7200	1.93e+01	1.074e+01	1.331e+01	7200	1.51e+01	9.913e+00	1.167e+01
Casead.ngfTanka.MINLP.3Tank.20FE	7200	1.97e+01	1.209e+01	1.505e+01	7200	1.68e+01	1.203e+01	1.808e+01	5773	8.40e+01	5.105e+00	3.183e+01
Casead.ngfTanka.MINLP.3Tank.40FE	7200	2.70e+01	1.086e+01	1.488e+01	7200	3.35e+01	1.203e+01	1.808e+01	7200	9.81e+01	5.084e+00	2.639e+02
Casead.ngfTanka.MECC.ITank.40FE	7200	4.79e+01	5.706e+00	1.298e+01	7200	2.52e+01	8.726e+00	1.167e+01	4810	9.38e+00	8.930e+00	9.163e+00
Casead.ngfTanka.MECC.ITank.40FE	7200	3.77e+01	6.760e+00	1.298e+01	7200	2.52e+01	8.726e+00	1.167e+01	4810	9.38e+00	8.930e+00	9.163e+00
Casead.ngfTanka.MECC.ITank.40FE	7200	2.81e+01	1.071e+01	1.489e+01	7200	2.72e+01	1.084e+01	1.489e+01	7200	9.89e+01	3.546e+00	3.271e+02
Casead.ngfTanka.MECC.ITank.40FE	7200	5.18e+01	1.037e+01	2.139e+01	7200	2.67e+01	1.490e+01	1.490e+01	7200	1.00e+02	3.324e+00	1.343e+04
Casead.ngfTanka.MECC.ITank.40FE	7200	3.76e+02	1.777e+06	1.777e+06	18	1.00e-04	1.777e+06	1.777e+06	7200	1.76e+01	1.510e+06	1.833e+06
ngw-r1-22020	0	–	–	–	–	–	–	–	–	–	–	–
ngw-r1-2316	0	–	–	–	–	–	–	–	–	–	–	–
ngw-r1-3510	7200	1.00e-04	4.376e+05	4.376e+05	0	–	–	–	20	1.00e-04	8.604e+05	8.604e+05
ngw-r1-53050	7200	2.04e+00	3.652e+06	3.728e+06	7200	2.16e+00	3.690e+06	3.771e+06	7200	4.17e+01	2.688e+06	4.612e+06
ngw-you-2020	7200	1.83e-01	1.774e+06	1.777e+06	7200	2.26e+01	1.467e+06	1.894e+06	7200	1.45e+01	1.527e+06	1.777e+06
ngw-you-2316	0	–	–	–	–	–	–	–	3	1.00e-04	4.376e+05	4.376e+05
ngw-you-30350	7200	5.31e+01	2.448e+06	3.769e+06	7200	5.43e+01	2.536e+06	5.545e+06	7200	6.42e+01	2.636e+06	7.363e+06
ngw-you-3510	9	1.00e-04	8.604e+05	8.604e+05	11	1.00e-04	9.338e+05	9.338e+05	162	1.00e-04	8.604e+05	8.604e+05
wds.signvar.backsubrog	7200	6.84e+01	1.121e+05	3.553e+05	7200	–	–	–	332	1.41e+01	1.053e+05	1.228e+05
wds.signvar.backsubrog	7200	–	–	–	–	–	–	–	–	–	–	–
wds.signvar.backsubrog	7200	–	–	–	–	–	–	–	–	–	–	–
wds.signvar.backsubrog	7200	–	–	–	–	–	–	–	–	–	–	–
wds.signvar.backsubrog	7200	1.96e+01	5.955e+06	7.410e+06	7200	–	–	–	1084	–	–	0.000e+00
wds.signvar.backsubrog	7200	–	–	–	–	–	–	–	974	–	–	0.000e+00
wds.signvar.backsubrog	7200	1.96e+01	5.955e+06	7.410e+06	7200	–	–	–	445	1.91e+01	5.293e+06	6.541e+06
wds.signvar.backsubrog	7200	–	–	–	–	–	–	–	7200	1.00e-04	2.073e+06	0.000e+00
wds.signvar.backsubrog	7200	–	–	–	–	–	–	–	2272	1.00e-04	1.609e+06	0.000e+00
wds.signvar.backsubrog	7200	3.14e+01	3.620e+05	5.280e+05	7200	2.38e-01	4.190e+05	4.200e+05	497	2.86e+00	4.070e+05	4.190e+05

Gap = 100 * (UB-LB) / UB; Termination Criteria: Gap = 1 × 10⁻⁴ or Time = 7200 s

Table S21: 60 minlp.org Test Cases – Academic Solvers

Problem Name	MISO Framework				SCIP 3.0				Couenne 0.4			
	Time	Gap	LB	UB	Time	Gap	LB	UB	Time	Gap	LB	UB
ConventLional	0	2.30e+01	-1.193e+05	-	14	1.00e-04	4.823e+02	4.825e+02	741	7.61e+00	-1.000e+50	-
Escobar_HEN1	7200	1.43e-01	8.322e+05	8.334e+05	7200	8.76e+00	1.411e+05	1.530e+05	1879	1.64e+00	6.236e+05	6.300e+05
Escobar_HEN2	2691	1.00e-04	6.420e+04	6.420e+04	7200	9.76e+01	6.311e+05	6.390e+05	2595	1.39e+01	5.529e+04	6.421e+04
GH-Ethanol1_model_EIgh	1	1.00e-04	-1.576e+02	-1.576e+02	7200	6.39e+01	-2.283e+02	-1.576e+02	2440	1.00e-04	-1.576e+02	-1.576e+02
GH-Ethanol1_model_LR	1	1.00e-04	-3.543e+02	-3.543e+02	7200	3.21e+02	-5.011e+02	-5.011e+02	3	1.00e-04	-5.011e+02	-5.011e+02
MITC_EX1	7200	4.50e-01	-3.916e+02	-3.916e+02	28	1.00e-04	-3.524e+02	-3.524e+02	7200	2.41e+01	-4.860e+02	-3.916e+02
MITC_EX1a	7200	1.68e-01	-1.213e+03	-4.805e+02	7200	6.53e+01	-7.407e+02	-4.482e+02	7200	5.44e+02	-2.834e+03	-4.333e+02
MITC_EX1C	7200	1.64e+02	-1.762e+03	-6.674e+03	7200	8.08e-01	-7.157e+03	-6.840e+02	7200	9.09e+02	-6.840e+02	-6.840e+02
MITC_EX2	13	1.00e-04	-7.081e+03	-7.081e+03	7200	2.64e+00	-6.075e+03	-5.921e+03	2566	2.90e+01	-6.813e+03	-5.280e+03
MITC_EX5	7200	3.0e+00	-5.419e+03	-5.925e+03	7200	2.20e+01	-6.479e+03	-5.309e+03	-	-	-	-
MITC_EX6	7200	2.81e+00	-6.002e+03	-3.335e+02	7200	2.20e+01	-1.519e+04	-	-	-	-	-
STG_EX1	7200	5.83e+02	-2.278e+03	-3.335e+02	7200	-	-1.012e+04	-	-	-	-	-
STG_EX1a	7200	2.01e+02	-1.178e+03	-3.910e+02	7200	-	-3.417e+04	-	-	-	-	-
STG_EX1b	7200	1.65e+02	-1.239e+03	-4.676e+02	7200	1.53e+04	-2.278e+04	-1.481e+02	1590	1.00e+04	-1.780e+04	-1.759e+02
STG_EX1C	7200	1.72e+02	-1.901e+03	-6.984e+02	7200	1.00e-04	6.068e+05	6.068e+05	3	1.00e-04	1.000e+50	-
STG_EX5	7200	5.53e+00	-6.108e+03	-5.788e+03	7200	-	-7.689e+04	-	2252	1.00e-04	6.068e+05	5.545e+05
STG_EX6	383	1.00e-04	-5.166e+03	-5.166e+03	7200	-	-1.001e+05	-	613	1.00e-04	6.068e+05	5.545e+05
ahmetovic_Ex1_NoBps	2	1.00e-04	6.068e+05	6.068e+05	1214	1.00e-04	6.068e+05	6.068e+05	684	1.00e-04	6.068e+05	5.545e+05
ahmetovic_Ex1_WithBps	7200	7.37e+01	1.051e+06	4.003e+06	7200	5.73e+01	1.044e+06	2.443e+06	2669	3.68e+01	1.044e+06	1.651e+06
ahmetovic_Ex2_NoBps	7200	1.03e+00	1.052e+06	1.063e+06	7200	5.42e+00	1.046e+06	1.063e+06	-	-	-	-
ahmetovic_Ex2_WithBps	7200	1.03e+00	1.052e+06	1.063e+06	7200	5.42e+00	1.046e+06	1.063e+06	-	-	-	-
batchplant_monconvex1	13	1.04e-04	2.855e+05	2.855e+05	-	-	-	-	-	-	-	-
batchplant_monconvex2	13	1.94e-04	2.687e+06	2.687e+06	-	-	-	-	-	-	-	-
bep5	7200	1.20e+00	-9.633e-01	-9.519e-01	7200	4.83e+00	-9.979e-01	-9.519e-01	607	1.91e-02	-9.749e-01	-9.747e-01
bep6	7200	4.40e+00	-9.994e-01	-9.573e-01	7200	3.87e+00	-1.000e+00	-9.628e-01	-	-	-	-
bep7	7200	5.59e-01	-9.684e-01	-9.630e-01	7200	-	-1.000e+00	-	-	-	-	-
bep8	7200	1.04e+00	-9.798e-01	-9.740e-01	7200	-	-1.000e+00	-	8	-	-1.038e+11	-
caso-1-sec-v2	1409	2.26e+00	3.787e+12	3.749e+03	7200	1.00e-04	3.483e+05	3.483e+05	-	-	-	-
cuiz-combined	7200	3.57e-01	3.471e+05	3.483e+05	59	1.00e-04	3.483e+05	3.483e+05	-	-	-	-
youyounv1-chain_design1	7200	1.00e-04	2.260e+03	2.260e+03	2	4.43e-04	2.260e+03	2.260e+03	-	-	-	-
youyounv1-chain_design2	7200	1.00e-04	2.260e+03	2.260e+03	2	1.00e-04	2.260e+03	2.260e+03	-	-	-	-
zondervan_IC_convex	0	1.00e-04	5.782e+05	5.782e+05	7	1.00e-04	5.782e+05	5.782e+05	7155	1.35e+01	5.782e+05	5.854e+05
zondervan_IC_nonconvex	7200	7.23e-03	5.781e+05	5.782e+05	7	1.00e-04	5.782e+05	5.782e+05	7200	1.35e+01	5.006e+05	5.854e+05
CascadeIngTanka_MINLP_1Tank_20FE	7200	7.43e+00	8.483e+00	9.163e+00	7200	1.42e-02	9.163e+00	9.163e+00	-	-	-	-
CascadeIngTanka_MINLP_1Tank_40FE	7200	3.57e+01	7.895e+00	1.227e+01	7200	6.45e+00	1.023e+01	1.167e+01	-	-	-	-
CascadeIngTanka_MINLP_3Tank_20FE	7200	1.97e+01	1.209e+01	1.505e+01	7200	4.11e+00	1.428e+01	1.489e+01	-	-	-	-
CascadeIngTanka_MINLP_3Tank_40FE	7200	2.70e+01	1.086e+01	1.488e+01	7200	1.21e+01	1.308e+01	1.488e+01	-	-	-	-
CascadeIngTanka_MJCC_1Tank_40FE	7200	4.79e+01	5.706e+00	1.298e+01	7200	3.88e+01	5.887e+00	9.624e+00	-	-	-	-
CascadeIngTanka_MJCC_1Tank_20FE	7200	3.77e+01	6.760e+00	1.298e+01	7200	3.02e+01	8.148e+00	1.167e+01	-	-	-	-
CascadeIngTanka_MJCC_1Tank_40FE	7200	2.81e+01	1.071e+01	1.489e+01	7200	3.38e+01	1.001e+01	1.490e+01	-	-	-	-
CascadeIngTanka_MJCC_3Tank_20FE	7200	5.18e+01	1.037e+01	2.139e+01	7200	3.48e+01	1.016e+01	1.490e+01	6000	-	1.079e+01	-
CascadeIngTanka_MJCC_3Tank_40FE	7200	3.76e+02	1.777e+06	1.777e+06	7200	3.48e+01	1.016e+01	1.490e+01	-	-	-	-
ngw-rl-22020	0	1.00e-04	4.376e+05	4.376e+05	0	1.00e-04	4.376e+05	4.376e+05	4688	1.00e-04	1.777e+06	1.777e+06
ngw-rl-2316	1	1.00e-04	8.604e+05	8.604e+05	16	1.03e-04	8.604e+05	8.604e+05	2	1.00e-04	4.376e+05	4.376e+05
ngw-rl-3510	7200	2.04e+00	3.652e+06	3.728e+06	7200	3.88e+01	3.123e+06	3.733e+06	5	1.00e-04	8.604e+05	8.604e+05
ngw-you-2020	7200	1.83e-01	1.774e+06	1.777e+06	7200	3.88e+01	1.777e+06	1.777e+06	7200	4.95e+01	2.743e+06	5.437e+06
ngw-you-2316	0	1.00e-04	4.376e+05	4.376e+05	2	1.00e-04	4.376e+05	4.376e+05	7200	7.13e+00	1.667e+06	1.955e+06
ngw-you-3050	7200	3.51e+01	2.448e+06	3.769e+06	7200	3.02e+01	2.755e+06	3.909e+06	7200	1.00e-04	4.376e+05	4.376e+05
ngw-you-3510	9	1.00e-04	8.604e+05	8.604e+05	4	1.00e-04	8.604e+05	8.604e+05	26	1.00e-04	2.441e+06	2.441e+06
wda-signvar-blacksburg	7200	6.84e+01	1.121e+05	3.553e+05	7200	1.32e+01	1.164e+05	1.341e+05	1	-	1.000e+50	-
wda-signvar-rossiron	7200	6.84e+01	1.121e+05	3.553e+05	7200	6.39e+01	1.754e+05	1.754e+05	-	-	-	-
wda-signvar-rosspoly1	7200	6.84e+01	1.121e+05	3.553e+05	7200	6.39e+01	1.754e+05	1.754e+05	5370	-	2.561e+04	-
wda-signvar-rosspoly2	7200	6.84e+01	1.121e+05	3.553e+05	7200	6.39e+01	1.754e+05	1.754e+05	7200	-	2.073e+06	-
wda-signvar-rosspoly3	7200	1.96e+01	5.955e+06	7.410e+06	0	-	-	-	-	-	-	-
wda-signvar-rosspoly4	7200	1.96e+01	5.955e+06	7.410e+06	7200	-	-	-	-	-	-	-
wda-signvar-rosspoly5	7200	1.96e+01	5.955e+06	7.410e+06	7200	-	-	-	-	-	-	-
wda-signvar-pepeara	7200	-	1.636e+06	1.636e+06	-	-	-	-	-	-	-	-
wda-signvar-shamilr	7200	3.14e+01	3.620e+05	5.280e+05	23	1.00e-04	4.190e+05	4.190e+05	-	-	-	-

Gap = 100 * (UB-LB) / UB ; Termination Criteria: Gap = 1e-4% or Time = 7200 s

Table S22: 100 MINLP Library Test Cases – Commercial Solvers

Problem Name	MISO Framework					BARON 12.3.3					LINDO 8.0					
	Time	Gap	LB	UB	Time	Gap	LB	UB	Time	Gap	LB	UB	Time	Gap	LB	UB
fo7	196	1.00e-04	2.073e+01	2.073e+01	7200	2.35e+01	1.386e+01	2.073e+01	7200	7.20e+01	7.750e+00	2.764e+01	7200	7.20e+01	7.750e+00	2.764e+01
fo7.2	176	1.00e-04	1.775e+01	1.775e+01	7200	2.10e+01	1.402e+01	1.775e+01	7200	6.19e+01	8.652e+00	2.273e+01	7200	6.19e+01	8.652e+00	2.273e+01
fo7.ar25.1	92	1.00e-04	2.309e+01	2.309e+01	7200	2.14e+01	1.817e+01	2.309e+01	7200	6.28e+01	1.224e+01	3.259e+01	7200	6.28e+01	1.224e+01	3.259e+01
fo7.ar25.1	84	1.00e-04	2.496e+01	2.496e+01	4972	1.88e+01	2.352e+01	2.496e+01	7200	5.07e+01	2.864e+01	2.864e+01	7200	5.07e+01	2.864e+01	2.864e+01
fo7.ar4.1	75	1.00e-04	2.252e+01	2.252e+01	4972	1.88e+01	2.352e+01	2.252e+01	7200	6.07e+01	1.140e+01	3.076e+01	7200	6.07e+01	1.140e+01	3.076e+01
fo7.ar4.1	75	1.00e-04	2.252e+01	2.252e+01	4972	1.88e+01	2.352e+01	2.252e+01	7200	6.07e+01	1.140e+01	3.076e+01	7200	6.07e+01	1.140e+01	3.076e+01
fo7.ar5.1	26	1.00e-04	1.775e+01	1.775e+01	2025	1.00e-04	2.073e+01	1.775e+01	7200	4.65e+01	1.112e+01	2.081e+01	7200	4.65e+01	1.112e+01	2.081e+01
fo8	378	1.00e-04	2.238e+01	2.238e+01	7200	5.41e+01	1.131e+01	2.238e+01	7200	1.00e-04	3.000e+00	0.000e+00	7200	1.00e-04	3.000e+00	0.000e+00
fo8.ar25.1	3674	1.00e-04	2.805e+01	2.805e+01	7200	3.72e+01	2.026e+01	2.805e+01	7200	1.00e-04	7.465e+00	0.000e+00	7200	1.00e-04	7.465e+00	0.000e+00
fo8.ar25.1	2634	1.00e-04	3.034e+01	3.034e+01	7200	3.72e+01	2.026e+01	3.034e+01	7200	1.00e-04	1.315e+01	0.000e+00	7200	1.00e-04	1.315e+01	0.000e+00
fo8.ar25.1	131	1.00e-04	2.391e+01	2.391e+01	7200	3.85e+01	1.575e+01	2.391e+01	7200	7.97e+01	8.598e+00	4.230e+01	7200	7.97e+01	8.598e+00	4.230e+01
fo8.ar4.1	138	1.00e-04	2.238e+01	2.238e+01	7200	3.85e+01	1.575e+01	2.238e+01	7200	8.60e+01	8.598e+00	6.132e+01	7200	8.60e+01	8.598e+00	6.132e+01
fo8.ar4.1	379	1.00e-04	2.238e+01	2.238e+01	7200	3.85e+01	1.575e+01	2.238e+01	7200	8.18e+01	5.301e+00	2.909e+01	7200	8.18e+01	5.301e+00	2.909e+01
fo8.ar5.1	1496	1.00e-04	2.346e+01	2.346e+01	7200	6.44e+01	9.843e+00	2.346e+01	7200	1.00e-04	6.008e+00	0.000e+00	7200	1.00e-04	6.008e+00	0.000e+00
fo9	9.83e+00	2.903e+01	3.219e+01	3.219e+01	7200	1.07e+01	1.07e+01	3.219e+01	7200	1.00e-04	9.535e+00	0.000e+00	7200	1.00e-04	9.535e+00	0.000e+00
fo9.ar25.1	7200	9.83e+00	2.903e+01	3.219e+01	7200	1.07e+01	1.07e+01	2.903e+01	7200	1.00e-04	6.598e+00	0.000e+00	7200	1.00e-04	6.598e+00	0.000e+00
fo9.ar25.1	7200	9.83e+00	2.903e+01	3.219e+01	7200	1.07e+01	1.07e+01	2.903e+01	7200	1.00e-04	6.598e+00	0.000e+00	7200	1.00e-04	6.598e+00	0.000e+00
fo9.ar25.1	6960	1.05e-04	2.465e+01	2.465e+01	7200	8.62e+00	9.180e+00	2.465e+01	7200	1.00e-04	3.000e+00	0.000e+00	7200	1.00e-04	3.000e+00	0.000e+00
fo9.ar4.1	7200	2.30e+00	2.292e+01	2.292e+01	7200	1.00e-04	1.065e+01	2.292e+01	7200	1.00e-04	4.342e+00	0.000e+00	7200	1.00e-04	4.342e+00	0.000e+00
fo9.ar5.1	7200	1.00e-04	3.780e+01	3.780e+01	7200	1.00e-04	1.065e+01	3.780e+01	7200	1.00e-04	3.780e+01	3.780e+01	7200	1.00e-04	3.780e+01	3.780e+01
m3	0	1.00e-04	8.226e+01	8.226e+01	102	1.00e-04	8.226e+01	8.226e+01	192	1.00e-04	8.226e+01	8.226e+01	192	1.00e-04	8.226e+01	8.226e+01
m6	1	1.00e-04	1.068e+02	1.068e+02	1551	1.00e-04	1.068e+02	1.068e+02	2081	1.00e-04	1.068e+02	1.068e+02	2081	1.00e-04	1.068e+02	1.068e+02
m7	1	1.00e-04	1.436e+02	1.436e+02	23	1.00e-04	1.436e+02	1.436e+02	219	1.00e-04	1.436e+02	1.436e+02	219	1.00e-04	1.436e+02	1.436e+02
m7.ar25.1	7	1.00e-04	1.902e+02	1.902e+02	20	1.00e-04	1.902e+02	1.902e+02	906	1.00e-04	1.902e+02	1.902e+02	906	1.00e-04	1.902e+02	1.902e+02
m7.ar3.1	5	1.00e-04	1.436e+02	1.436e+02	234	1.00e-04	1.436e+02	1.436e+02	6208	1.00e-04	1.436e+02	1.436e+02	6208	1.00e-04	1.436e+02	1.436e+02
m7.ar4.1	1	1.00e-04	1.068e+02	1.068e+02	201	1.00e-04	1.068e+02	1.068e+02	2786	1.00e-04	1.068e+02	1.068e+02	2786	1.00e-04	1.068e+02	1.068e+02
m7.ar5.1	1	1.00e-04	1.068e+02	1.068e+02	598	1.00e-04	1.068e+02	1.068e+02	1352	1.00e-04	1.068e+02	1.068e+02	1352	1.00e-04	1.068e+02	1.068e+02
no.ar25.1	1238	1.00e-04	1.078e+02	1.078e+02	7200	2.53e+01	8.075e+00	1.078e+02	7200	6.06e+01	4.928e+01	1.189e+02	7200	6.06e+01	4.928e+01	1.189e+02
no.ar25.1	1034	1.00e-04	1.078e+02	1.078e+02	7200	2.53e+01	8.075e+00	1.078e+02	7200	6.06e+01	4.928e+01	1.189e+02	7200	6.06e+01	4.928e+01	1.189e+02
no.ar4.1	910	1.00e-04	1.078e+02	1.078e+02	7200	2.53e+01	8.075e+00	1.078e+02	7200	7.51e+01	3.757e+01	1.508e+02	7200	7.51e+01	3.757e+01	1.508e+02
no.ar4.1	424	1.00e-04	9.852e+01	9.852e+01	7200	2.38e+01	7.653e+01	9.852e+01	7200	6.06e+01	3.813e+01	1.122e+02	7200	6.06e+01	3.813e+01	1.122e+02
no.ar5.1	334	1.02e-04	9.062e+01	9.062e+01	7200	1.19e+01	7.983e+01	9.062e+01	7200	9.062e+01	3.611e+01	1.373e+02	7200	9.062e+01	3.611e+01	1.373e+02
o7	7200	3.02e+00	1.277e+02	1.277e+02	7200	4.91e+01	6.959e+01	1.277e+02	7200	8.12e+01	3.091e+01	1.647e+02	7200	8.12e+01	3.091e+01	1.647e+02
o7.2	1348	1.00e-04	1.169e+02	1.169e+02	7200	3.99e+01	1.231e+01	1.169e+02	7200	8.43e+01	1.949e+01	1.239e+02	7200	8.43e+01	1.949e+01	1.239e+02
o7.ar25.1	4957	1.00e-04	1.404e+02	1.404e+02	7200	2.45e+01	1.066e+02	1.404e+02	7200	6.85e+01	4.848e+01	1.575e+02	7200	6.85e+01	4.848e+01	1.575e+02
o7.ar2.1	2147	1.00e-04	1.404e+02	1.404e+02	5893	1.00e-04	1.404e+02	1.404e+02	7200	1.00e-04	4.953e+01	0.000e+00	7200	1.00e-04	4.953e+01	0.000e+00
o7.ar3.1	6388	1.00e-04	1.379e+02	1.379e+02	7200	3.29e+01	9.480e+01	1.379e+02	7200	7.01e+01	4.425e+01	1.477e+02	7200	7.01e+01	4.425e+01	1.477e+02
o7.ar4.1	7200	1.00e-04	1.185e+02	1.185e+02	7200	2.18e+01	9.428e+01	1.185e+02	7200	7.15e+01	4.387e+01	1.538e+02	7200	7.15e+01	4.387e+01	1.538e+02
o7.ar5.1	2830	1.04e-04	1.169e+02	1.169e+02	7200	2.18e+01	9.428e+01	1.169e+02	7200	1.00e-04	4.681e+01	0.000e+00	7200	1.00e-04	4.681e+01	0.000e+00
o8.ar4.1	7200	9.44e+00	2.201e+02	2.431e+02	7200	2.18e+01	9.428e+01	2.201e+02	7200	1.00e-04	3.175e+01	0.000e+00	7200	1.00e-04	3.175e+01	0.000e+00
o9.ar4.1	7200	2.95e+01	2.140e+02	3.036e+02	7200	2.18e+01	9.428e+01	2.140e+02	7200	1.00e-04	7.667e+00	7.667e+00	7200	1.00e-04	7.667e+00	7.667e+00
ex122.1	0	1.00e-04	7.667e+00	7.667e+00	0	1.00e-04	7.667e+00	7.667e+00	0	1.00e-04	7.667e+00	7.667e+00	0	1.00e-04	7.667e+00	7.667e+00
ex122.5	0	1.00e-04	3.100e+01	3.100e+01	0	1.00e-04	3.100e+01	3.100e+01	0	1.00e-04	3.100e+01	3.100e+01	0	1.00e-04	3.100e+01	3.100e+01
ex122.6	0	1.00e-04	-1.700e+01	-1.700e+01	0	1.00e-04	-1.700e+01	-1.700e+01	0	1.00e-04	-1.700e+01	-1.700e+01	0	1.00e-04	-1.700e+01	-1.700e+01
ex122.3	7200	1.73e-01	1.547e+05	1.550e+05	138	1.00e-04	1.550e+05	1.550e+05	7200	9.39e-01	1.536e+05	1.550e+05	7200	9.39e-01	1.536e+05	1.550e+05
ex121.3	2	1.00e-04	8.340e+04	8.340e+04	11	1.00e-04	8.340e+04	8.340e+04	24	1.00e-04	8.340e+04	8.340e+04	24	1.00e-04	8.340e+04	8.340e+04
ex12.4	7200	1.50e+00	8.081e+04	8.204e+04	11	1.00e-04	8.204e+04	8.204e+04	6	1.00e-04	8.204e+04	8.204e+04	6	1.00e-04	8.204e+04	8.204e+04
ex12.2	5	1.00e-04	1.289e+05	1.289e+05	1	1.00e-04	1.343e+05	1.289e+05	35	1.00e-04	1.289e+05	1.289e+05	35	1.00e-04	1.289e+05	1.289e+05
ex12.5	1047	1.00e-04	1.289e+05	1.289e+05	1	1.00e-04	1.343e+05	1.289e+05	66	1.00e-04	1.289e+05	1.289e+05	66	1.00e-04	1.289e+05	1.289e+05
nv50.1	0	1.00e-04	1.247e+01	1.247e+01	0	1.00e-04	1.247e+01	1.247e+01	0	1.00e-04	1.247e+01	1.247e+01	0	1.00e-04	1.247e+01	1.247e+01
nv50.2	0	1.00e-04	5.966e+00	5.966e+00	0	1.00e-04	5.966e+00	5.966e+00	0	1.00e-04	5.966e+00	5.966e+00	0	1.00e-04	5.966e+00	5.966e+00
nv50.3	0	1.00e-04	7.200e-01	7.200e-01	0	1.00e-04	7.200e-01	7.200e-01	0	1.00e-04	7.200e-01	7.200e-01	0	1.00e-04	7.200e-01	7.2

Table S22 (100 MINLP Library Test Cases – Commercial Solvers) continued

Problem Name	MISO Framework				BARON 12.3.3				LINDO 8.0			
	Time	Gap	LB	UB	Time	Gap	LB	UB	Time	Gap	LB	UB
fac1	0	1.00e-04	1.609e+08	1.609e+08	–	–	–	–	0	1.00e-04	1.609e+08	1.609e+08
fac2	0	1.00e-04	3.318e+08	3.318e+08	–	–	–	–	3	1.00e-04	3.318e+08	3.318e+08
gasnet	7200	5.22e+01	3.344e+06	6.999e+06	7200	6.03e+01	2.790e+06	7.024e+06	7200	6.58e+01	2.396e+06	6.999e+06
gastrans	0	1.00e-04	–	–	0	1.00e-04	8.909e+01	8.909e+01	0	1.00e-04	8.909e+01	8.909e+01
gear2	0	1.00e-04	-1.051e-07	8.949e-07	0	1.00e-04	-2.221e-07	7.779e-07	0	1.00e-04	0.000e+00	1.827e-08
gear3	0	1.00e-04	-2.221e-07	7.779e-07	0	1.00e-04	0.000e+00	2.021e-07	0	1.00e-04	0.000e+00	2.358e-09
gear4	0	1.00e-04	-4.959e-07	5.041e-07	0	1.00e-04	0.000e+00	4.755e-07	0	1.00e-04	0.000e+00	8.206e-07
hmtellman	24	1.00e-04	1.643e+00	1.643e+00	0	1.00e-04	1.643e+00	1.643e+00	173	1.00e-04	1.643e+00	1.643e+00
johnall	0	1.00e-04	1.300e+01	1.300e+01	0	1.00e-04	1.300e+01	1.300e+01	0	1.00e-04	1.300e+01	1.300e+01
johnall	10	1.00e-04	-2.247e+02	-2.247e+02	2	1.00e-04	-2.247e+02	-2.247e+02	56	1.00e-04	-2.247e+02	-2.247e+02
miniphix	1	1.00e-04	3.167e+02	3.167e+02	7200	–	–	–	7200	5.98e+06	-1.262e+07	3.167e+02
ortez	0	1.00e-04	-9.532e+03	-9.532e+03	0	1.00e-04	-9.532e+03	-9.532e+03	3	1.00e-04	-9.532e+03	-9.532e+03
parallel	222	4.06e-04	9.248e+02	9.248e+02	12	1.00e-04	9.248e+02	9.248e+02	73	1.00e-04	9.248e+02	9.248e+02
pump	1012	1.00e-04	1.868e+05	1.868e+05	1	1.00e-04	1.868e+05	1.868e+05	1	1.00e-04	1.868e+05	1.868e+05
rsb	0	1.00e-04	-5.588e+01	-5.588e+01	1	1.00e-04	-5.588e+01	-5.588e+01	2	1.00e-04	-5.588e+01	-5.588e+01
rsb2b	0	1.00e-04	-5.588e+01	-5.588e+01	1	1.00e-04	-5.588e+01	-5.588e+01	2	1.00e-04	-5.588e+01	-5.588e+01
spring	0	1.00e-04	8.462e-01	8.462e-01	0	1.00e-04	8.462e-01	8.462e-01	1	1.00e-04	8.462e-01	8.462e-01
stocycle	1	1.00e-04	1.199e+05	1.199e+05	82	1.00e-04	1.199e+05	1.199e+05	7200	8.68e-01	1.199e+05	1.204e+05
synheat	7200	2.30e+01	1.194e+05	1.550e+05	345	1.00e-04	1.550e+05	1.550e+05	7200	3.18e+00	1.501e+05	1.550e+05
waterx	7200	–	–	–	7200	6.56e+01	3.366e+02	9.797e+02	7200	7.71e+01	2.178e+02	9.510e+02
Elay02H	1	1.00e-04	3.795e+01	3.795e+01	0	1.00e-04	3.795e+01	3.795e+01	0	1.00e-04	3.795e+01	3.795e+01
Elay02M	0	1.00e-04	3.795e+01	3.795e+01	0	1.00e-04	3.795e+01	3.795e+01	0	1.00e-04	3.795e+01	3.795e+01
Elay03H	11	1.00e-04	4.899e+01	4.899e+01	1	1.00e-04	4.899e+01	4.899e+01	26	1.00e-04	4.899e+01	4.899e+01
Elay03M	5	1.00e-04	4.899e+01	4.899e+01	0	1.00e-04	4.899e+01	4.899e+01	16	1.00e-04	4.899e+01	4.899e+01
Elay04H	113	1.00e-04	5.441e+01	5.441e+01	14	1.00e-04	5.441e+01	5.441e+01	725	1.00e-04	5.441e+01	5.441e+01
Elay04M	47	1.00e-04	5.441e+01	5.441e+01	4	1.00e-04	5.441e+01	5.441e+01	293	1.00e-04	5.441e+01	5.441e+01
Elay05H	7200	1.06e-01	6.450e+01	6.450e+01	2253	1.00e-04	6.450e+01	6.450e+01	6621	2.79e+01	4.648e+01	6.450e+01
Elay05M	4245	1.00e-04	6.450e+01	6.450e+01	164	1.00e-04	6.450e+01	6.450e+01	7200	1.52e+01	5.467e+01	6.450e+01
Elay06H	7200	8.63e+00	6.116e+01	6.693e+01	7200	2.85e+01	4.788e+01	6.693e+01	7200	3.88e+01	4.099e+01	6.693e+01
Elay06M	7200	3.68e+00	6.447e+01	6.693e+01	7200	5.54e+00	6.323e+01	6.693e+01	7200	3.06e+01	4.648e+01	6.693e+01

Gap $\equiv 100 \cdot \left(\frac{UB-LB}{LB} \right)$; Termination Criteria: Gap = $1 \times 10^{-4}\%$ or Time = 7200 s

Table S23: 100 MINLP Library Test Cases – Academic Solvers

Problem Name	MISO Framework					CoUnne 0.4						
	Time	Gap	LB	UB	Time	Gap	LB	UB	Time	Gap	LB	UB
fo7	196	1.00e-04	2.073e+01	2.073e+01	107	1.00e-04	2.073e+01	2.073e+01	7200	2.40e+01	1.576e+01	2.073e+01
fo7.2	176	1.00e-04	1.775e+01	1.775e+01	45	1.00e-04	1.775e+01	1.775e+01	7200	5.23e+00	1.682e+01	1.775e+01
fo7.ar25.1	92	1.00e-04	2.309e+01	2.309e+01	84	1.00e-04	2.309e+01	2.309e+01	4018	1.00e-04	2.309e+01	2.309e+01
fo7.ar22.1	96	1.00e-04	2.484e+01	2.484e+01	84	1.00e-04	2.484e+01	2.484e+01	1228	1.00e-04	2.484e+01	2.484e+01
fo7.ar4.1	75	1.00e-04	2.352e+01	2.352e+01	35	1.00e-04	2.352e+01	2.352e+01	4497	1.00e-04	2.073e+01	2.073e+01
fo7.ar5.1	26	1.00e-04	1.775e+01	1.775e+01	16	1.00e-04	1.775e+01	1.775e+01	2380	1.00e-04	1.775e+01	1.775e+01
fo7.ar15.1	378	1.00e-04	2.238e+01	2.238e+01	188	1.00e-04	2.238e+01	2.238e+01	7200	5.77e+01	1.010e+01	2.391e+01
fo8.ar25.1	3674	1.00e-04	2.805e+01	2.805e+01	244	1.00e-04	2.805e+01	2.805e+01	7200	5.12e+01	1.722e+01	3.532e+01
fo8.ar22.1	2634	1.00e-04	3.034e+01	3.034e+01	191	1.00e-04	3.034e+01	3.034e+01	7200	5.50e+01	1.306e+01	2.901e+01
fo8.ar23.1	131	1.00e-04	2.238e+01	2.238e+01	195	1.00e-04	2.238e+01	2.238e+01	7200	5.25e+01	1.207e+01	2.598e+01
fo8.ar4.1	138	1.00e-04	2.238e+01	2.238e+01	78	1.00e-04	2.238e+01	2.238e+01	7200	6.96e+01	7.291e+00	3.150e+01
fo8.ar5.1	379	1.00e-04	2.238e+01	2.238e+01	68	1.00e-04	2.238e+01	2.238e+01	7200	6.96e+01	7.291e+00	3.150e+01
fo9	1496	1.00e-04	2.346e+01	2.346e+01	1002	1.00e-04	2.346e+01	2.346e+01	7200	8.34e+01	9.182e+00	5.542e+01
fo9.ar25.1	7200	9.83e+00	2.903e+01	3.219e+01	6040	1.00e-04	3.219e+01	3.219e+01	7200	7.97e+01	7.935e+00	3.913e+01
fo9.ar22.1	7200	9.83e+00	2.952e+01	3.262e+01	1355	1.00e-04	3.262e+01	3.262e+01	7200	7.37e+01	1.014e+01	3.855e+01
fo9.ar4.1	6960	1.05e-04	2.465e+01	2.465e+01	316	1.00e-04	2.465e+01	2.465e+01	7200	6.90e+01	9.156e+00	2.956e+01
fo9.ar5.1	7200	2.30e+00	2.292e+01	2.346e+01	795	1.00e-04	2.346e+01	2.346e+01	7200	1.00e-04	3.780e+01	3.780e+01
m3	0	1.00e-04	8.226e+01	8.226e+01	4	1.00e-04	8.226e+01	8.226e+01	44	1.00e-04	8.226e+01	8.226e+01
m6	1	1.00e-04	1.068e+02	1.068e+02	7	1.00e-04	1.068e+02	1.068e+02	412	1.00e-04	1.068e+02	1.068e+02
m7	1	1.00e-04	1.436e+02	1.436e+02	1	1.00e-04	1.436e+02	1.436e+02	52	1.00e-04	1.436e+02	1.436e+02
m7.ar25.1	7	1.00e-04	1.902e+02	1.902e+02	6	1.00e-04	1.902e+02	1.902e+02	23	1.00e-04	1.902e+02	1.902e+02
m7.ar3.1	5	1.00e-04	1.436e+02	1.436e+02	5	1.00e-04	1.436e+02	1.436e+02	83	1.00e-04	1.068e+02	1.068e+02
m7.ar4.1	1	1.00e-04	1.068e+02	1.068e+02	9	1.00e-04	1.068e+02	1.068e+02	125	1.00e-04	1.068e+02	1.068e+02
m7.ar5.1	1238	1.00e-04	1.068e+02	1.068e+02	45	1.00e-04	1.068e+02	1.068e+02	107	1.00e-04	1.068e+02	1.068e+02
no7.ar25.1	1034	1.00e-04	1.078e+02	1.078e+02	55	1.00e-04	1.078e+02	1.078e+02	7200	2.36e+01	8.240e+01	1.078e+02
no7.ar22.1	910	1.00e-04	1.078e+02	1.078e+02	293	1.00e-04	1.078e+02	1.078e+02	7200	2.98e+01	7.678e+01	1.094e+02
no7.ar4.1	424	1.00e-04	9.852e+01	9.852e+01	205	1.00e-04	9.852e+01	9.852e+01	7200	2.75e+01	7.145e+01	9.852e+01
no7.ar5.1	334	1.02e-04	9.062e+01	9.062e+01	107	1.00e-04	9.062e+01	9.062e+01	7200	4.64e+01	7.223e+01	9.209e+01
o7.2	7200	3.02e+00	1.317e+02	1.317e+02	2838	1.00e-04	1.317e+02	1.317e+02	7200	3.16e+01	8.003e+01	1.169e+02
o7.ar25.1	1348	1.00e-04	1.169e+02	1.169e+02	1619	1.00e-04	1.169e+02	1.169e+02	7200	3.16e+01	8.003e+01	1.169e+02
o7.ar2.1	4957	1.00e-04	1.404e+02	1.404e+02	330	1.00e-04	1.404e+02	1.404e+02	7200	3.16e+01	8.003e+01	1.169e+02
o7.ar3.1	6388	1.00e-04	1.379e+02	1.379e+02	1126	1.00e-04	1.379e+02	1.379e+02	7200	9.92e+00	1.265e+02	1.404e+02
o7.ar4.1	7200	1.00e-04	1.185e+02	1.185e+02	1348	1.00e-04	1.185e+02	1.185e+02	7200	3.58e+01	8.856e+01	1.379e+02
o7.ar5.1	2830	1.04e-04	1.169e+02	1.169e+02	664	1.00e-04	1.169e+02	1.169e+02	7200	2.29e+01	9.013e+01	1.366e+02
o8.ar4.1	7200	9.44e+00	2.201e+02	2.431e+02	7200	8.89e+00	2.215e+02	2.431e+02	7200	6.41e+01	6.021e+01	2.660e+02
o9.ar4.1	7200	2.95e+01	2.140e+02	3.036e+02	7200	1.58e+01	1.989e+02	2.361e+02	7200	7.85e+01	6.021e+01	2.802e+02
ex1221	0	1.00e-04	7.667e+00	7.667e+00	0	1.00e-04	7.667e+00	7.667e+00	0	1.00e-04	7.667e+00	7.667e+00
ex1225	0	1.00e-04	3.100e+01	3.100e+01	0	1.00e-04	3.100e+01	3.100e+01	0	1.00e-04	3.100e+01	3.100e+01
ex1226	0	1.00e-04	-1.700e+01	-1.700e+01	0	1.00e-04	-1.700e+01	-1.700e+01	0	1.00e-04	-1.700e+01	-1.700e+01
ex1233	7200	1.73e-01	1.547e+05	1.550e+05	0	1.00e-04	8.340e+04	8.340e+04	7200	5.54e+00	1.464e+05	1.550e+05
ex1243	2	1.00e-04	8.340e+04	8.340e+04	2	1.00e-04	8.340e+04	8.340e+04	2	1.00e-04	8.340e+04	8.340e+04
ex1244	7200	1.50e+00	8.081e+04	8.204e+04	2	7.99e-04	8.204e+04	8.204e+04	4	1.00e-04	8.204e+04	8.204e+04
ex1245	5	1.00e-04	1.289e+05	1.289e+05	4	1.00e-04	1.289e+05	1.289e+05	12	1.00e-04	1.289e+05	1.289e+05
ex1252a	1047	1.00e-04	1.289e+05	1.289e+05	3	1.00e-04	1.289e+05	1.289e+05	11	1.00e-04	1.289e+05	1.289e+05
nv501	0	1.00e-04	1.247e+01	1.247e+01	0	1.00e-04	1.247e+01	1.247e+01	0	1.00e-04	1.247e+01	1.247e+01
nv502	0	1.00e-04	5.964e+00	5.964e+00	0	1.00e-04	5.964e+00	5.964e+00	0	1.00e-04	5.964e+00	5.964e+00
nv503	0	1.00e-04	7.200e-01	7.200e-01	0	1.00e-04	7.200e-01	7.200e-01	0	1.00e-04	7.200e-01	7.200e-01
nv504	0	1.00e-04	5.200e-01	5.200e-01	0	1.00e-04	5.200e-01	5.200e-01	0	1.00e-04	5.200e-01	5.200e-01
nv505	0	1.00e-04	1.770e+00	1.770e+00	0	1.00e-04	1.770e+00	1.770e+00	0	1.00e-04	1.770e+00	1.770e+00
nv506	0	1.00e-04	4.000e+00	4.000e+00	0	1.00e-04	4.000e+00	4.000e+00	0	1.00e-04	4.000e+00	4.000e+00
nv507	0	1.00e-04	2.345e+01	2.345e+01	0	1.00e-04	2.345e+01	2.345e+01	0	1.00e-04	2.345e+01	2.345e+01
nv516	0	1.00e-04	7.031e-01	7.031e-01	0	1.00e-04	7.031e-01	7.031e-01	0	1.00e-04	7.031e-01	7.031e-01
nv520	21	1.02e-04	2.309e+02	2.309e+02	0	1.00e-04	2.309e+02	2.309e+02	1	1.00e-04	2.309e+02	2.309e+02
nv521	0	1.00e-04	-5.685e+00	-5.685e+00	0	1.00e-04	-5.685e+00	-5.685e+00	0	1.00e-04	-5.685e+00	-5.685e+00
nv522	0	1.00e-04	6.058e+00	6.058e+00	0	1.00e-04	6.058e+00	6.058e+00	0	1.00e-04	6.058e+00	6.058e+00
st.e3.5	166	1.00e-04	7.667e+04	7.667e+04	7200	7.10e-04	6.487e+04	6.487e+04	44	1.00e-04	6.487e+04	6.487e+04
tl.t1.2	7200	0	6.979e+00	6.487e+04	7200	1.00e-04	6.487e+04	6.487e+04	7200	1.00e-04	6.487e+04	6.487e+04
tl.t2	0	1.00e-04	5.300e+00	5.300e+00	0	1.00e-04	5.300e+00	5.300e+00	0	1.00e-04	5.300e+00	5.300e+00
tl.t4	14	1.00e-04	8.300e+00	8.300e+00	45	1.00e-04	8.300e+00	8.300e+00	7200	5.88e+01	3.415e+00	8.300e+00
tl.t5	7200	2.26e+01	8.280e+00	1.070e+01	7200	7.49e+01	2.682e+00	1.070e+01	7200	9.02e+01	1.063e+00	1.090e+01
tl.t6	7200	5.45e+01	9.149e+00	2.010e+01	7200	8.11e+01	2.923e+00	1.550e+01	7200	9.44e+01	1.026e+00	1.830e+01
tl.t7	7200	0	2.716e+00	0	0	2.716e+00	0	0	7200	5.25e+00	-1.216e+05	-1.156e+05
cec1.l1.3	209	1.00e-04	-1.157e+05	-1.157e+05	0	1.00e-04	-1.157e+05	-1.157e+05	0	1.00e-04	-1.157e+05	-1.156e+05
enip1.ac	7200	4.43e-01	-1.327e+05	-1.327e+05	0	1.00e-04	-1.327e+05	-1.327e+05	7200	5.25e+00	-1.216e+05	-1.156e+05

continued on the next page

Gap = 100 * ((UB-LB) / |UB|); Termination Criteria: Gap = 1e-4 % or Time = 7200 s

Table S23 (100 MINLP Library Test Cases – Academic Solvers) continued

Problem Name	MISO Framework				SCIP 3.0				Couenne 0.4			
	Time	Gap	LB	UB	Time	Gap	LB	UB	Time	Gap	LB	UB
fac1	0	1.00e-04	1.609e+08	1.609e+08	0	1.00e-04	1.609e+08	1.609e+08	-	-	-	-
fac2	0	1.00e-04	3.318e+08	3.318e+08	952	1.00e-04	3.318e+08	3.318e+08	-	-	-	-
gashet	7200	5.22e+01	3.344e+06	6.999e+06	7200	6.06e+01	3.192e+06	8.105e+06	7200	5.70e+01	3.044e+06	7.077e+06
gastrans	0	1.00e-04	-1.051e-07	8.949e-07	0	1.00e-04	8.909e+01	8.909e+01	-	-	0.000e+00	2.726e-08
gear2	0	1.00e-04	-2.221e-07	7.779e-07	0	1.00e-04	-1.000e-06	4.755e-07	0	1.00e-04	1.381e-06	1.381e-06
gear3	0	1.00e-04	-4.959e-07	5.041e-07	0	1.00e-04	-1.000e-06	2.358e-09	0	1.00e-04	-	-
gear4	24	1.00e-04	1.643e+00	1.643e+00	1	1.00e-04	0.000e+00	4.804e+00	1	1.00e-04	1.643e+00	1.643e+00
hmittelman	0	1.00e-04	1.300e+01	1.300e+01	0	1.00e-04	1.300e+01	1.300e+01	0	1.00e-04	1.300e+01	1.300e+01
johnall	10	1.00e-04	-2.247e+02	-2.247e+02	49	1.00e-04	-2.247e+02	-2.247e+02	5	1.00e-04	-2.247e+02	-2.247e+02
miniphix	1	1.00e-04	3.167e+02	3.167e+02	7200	1.00e-04	-	3.167e+02	-	-	-	-
ortez	0	1.00e-04	-9.532e+03	-9.532e+03	0	1.00e-04	-9.532e+03	-9.532e+03	-	-	-	-
parallel	222	4.06e-04	9.238e+02	9.238e+02	6991	5.33e-02	9.238e+02	9.238e+02	46	1.00e-04	9.238e+02	9.238e+02
pump	1012	1.00e-04	1.889e+05	1.889e+05	3	1.00e-04	1.889e+05	1.889e+05	9	1.00e-04	1.889e+05	1.889e+05
rsb	0	1.00e-04	-5.588e-01	-5.588e-01	0	1.00e-04	-5.588e-01	-5.588e-01	8	1.00e-04	-5.588e-01	-5.588e-01
rs2bpb	0	1.00e-04	-5.588e-01	-5.588e-01	0	1.00e-04	-5.588e-01	-5.588e-01	12	1.00e-04	-5.588e-01	-5.588e-01
spinning	1	1.00e-04	8.462e-01	8.462e-01	0	1.00e-04	8.462e-01	8.462e-01	0	1.00e-04	8.462e-01	8.462e-01
stockcycle	1	1.00e-04	1.199e+05	1.199e+05	203	1.00e-04	1.199e+05	1.199e+05	-	-	-	-
synheat	7200	2.30e+01	1.194e+05	1.550e+05	7200	8.46e+00	1.419e+05	1.550e+05	7200	6.15e+00	1.455e+05	1.550e+05
waterx	7200	-	-	-	9.126e+02	9.126e+02	9.126e+02	9.126e+02	7200	3.80e+01	5.904e+02	9.520e+02
E1ay02H	1	1.00e-04	3.795e+01	3.795e+01	0	1.00e-04	3.795e+01	3.795e+01	0	1.00e-04	3.795e+01	3.795e+01
E1ay02M	0	1.00e-04	3.795e+01	3.795e+01	0	1.00e-04	3.795e+01	3.795e+01	0	1.00e-04	3.795e+01	3.795e+01
E1ay03H	11	1.00e-04	4.899e+01	4.899e+01	0	1.00e-04	4.899e+01	4.899e+01	2	1.00e-04	4.899e+01	4.899e+01
E1ay03M	5	1.00e-04	4.899e+01	4.899e+01	0	1.00e-04	4.899e+01	4.899e+01	2	1.00e-04	4.899e+01	4.899e+01
E1ay04H	113	1.00e-04	5.441e+01	5.441e+01	5	1.00e-04	5.441e+01	5.441e+01	15	1.00e-04	5.441e+01	5.441e+01
E1ay04M	47	1.00e-04	5.441e+01	5.441e+01	2	1.00e-04	5.441e+01	5.441e+01	3	1.00e-04	5.441e+01	5.441e+01
E1ay05H	7200	1.06e-01	6.450e+01	6.450e+01	317	1.00e-04	6.450e+01	6.450e+01	991	1.00e-04	6.450e+01	6.450e+01
E1ay05M	4245	1.00e-04	6.450e+01	6.450e+01	62	1.00e-04	6.450e+01	6.450e+01	140	1.00e-04	6.450e+01	6.450e+01
E1ay06H	7200	8.63e+00	6.116e+01	6.693e+01	7200	5.15e+00	6.348e+01	6.693e+01	7200	1.78e+01	5.521e+01	6.693e+01
E1ay06M	7200	3.68e+00	6.447e+01	6.693e+01	3110	1.00e-04	6.693e+01	6.693e+01	7200	2.91e-02	6.693e+01	6.693e+01

Gap $\equiv 100 \cdot \left(\frac{UB-LB}{LB} \right)$; Termination Criteria: Gap = $1 \times 10^{-4}\%$ or Time = 7200 s

Table S24: 82 GLOBALlib Test Cases – Commercial Solvers

Problem Name	MISO Framework												BARON 12.3.3												LINDO 8.0											
	Time			Gap			LB			UB			Time			Gap			LB			UB														
	Time	Gap	LB	Time	Gap	LB	Time	Gap	UB	Time	Gap	LB	Time	Gap	UB	Time	Gap	LB	Time	Gap	UB															
ex14.1.1	0	1.00e-04	-1.000e-06	5.294e-23	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	-1.000e-10	-8.881e-16	4.436e-12	4.436e-12																
ex14.1.2	0	1.00e-04	-1.000e-06	-9.869e-18	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	1	1.00e-04	0.000e+00	0.000e+00	0.000e+00	1	1.00e-04	-6.000e-10	-2.698e-17	0.000e+00	0.000e+00																
ex14.1.3	0	1.00e-04	-1.000e-06	4.825e-14	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0.000e+00																
ex14.2.1	0	1.00e-04	-1.000e-06	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0.000e+00																
ex14.2.2	0	1.00e-04	-1.000e-06	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0.000e+00																
ex14.2.3	0	1.00e-04	-1.000e-06	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0.000e+00																
ex14.2.4	0	1.00e-04	-1.000e-06	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0.000e+00																
ex14.1.4	0	1.00e-04	-1.000e-06	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0.000e+00	0.000e+00																
ex4.1.1.7	0	1.00e-04	-7.500e+00	-1.674e+01	0	1.00e-04	-7.500e+00	-1.674e+01	0	1.00e-04	-7.500e+00	-1.674e+01	0	1.00e-04	-7.500e+00	-1.674e+01	0	1.00e-04	-1.674e+01	-1.674e+01																
ex5.4.1.3	0	1.00e-04	-5.508e+00	-4.845e+03	0	1.00e-04	-5.508e+00	-4.845e+03	0	1.00e-04	-5.508e+00	-4.845e+03	0	1.00e-04	-5.508e+00	-4.845e+03	0	1.00e-04	-5.508e+00	-5.508e+00																
ex5.4.4	265	1.00e-04	1.008e+04	1.008e+04	12	1.00e-04	1.008e+04	1.008e+04	12	1.00e-04	1.008e+04	1.008e+04	153	1.00e-04	1.008e+04	1.008e+04	153	1.00e-04	1.008e+04	1.008e+04																
ex7.2.1	1	7.07e-04	1.227e+03	1.227e+03	7200	8.70e-02	1.227e+03	1.227e+03	7200	7.02e-01	1.227e+03	1.227e+03	5	1.00e-04	1.227e+03	1.227e+03	5	1.00e-04	1.227e+03	1.227e+03																
ex7.2.2	2906	3.55e-04	-3.888e-01	-3.888e-01	0	1.00e-04	-3.888e-01	-3.888e-01	0	1.00e-04	-3.888e-01	-3.888e-01	2	1.00e-04	-3.888e-01	-3.888e-01	2	1.00e-04	-3.888e-01	-3.888e-01																
ex7.2.3	10	1.00e-04	3.918e+00	3.918e+00	1	1.00e-04	3.918e+00	3.918e+00	1	1.00e-04	3.918e+00	3.918e+00	35	1.00e-04	3.918e+00	3.918e+00	35	1.00e-04	3.918e+00	3.918e+00																
ex7.2.4	0	1.00e-04	3.417e-01	3.417e-01	0	1.00e-04	3.417e-01	3.417e-01	0	1.00e-04	3.417e-01	3.417e-01	1	1.00e-04	3.417e-01	3.417e-01	1	1.00e-04	3.417e-01	3.417e-01																
ex7.3.1	0	1.00e-04	1.090e+00	1.090e+00	0	1.00e-04	1.090e+00	1.090e+00	0	1.00e-04	1.090e+00	1.090e+00	8	1.00e-04	1.090e+00	1.090e+00	8	1.00e-04	1.090e+00	1.090e+00																
ex7.3.2	1	1.00e-04	6.275e+00	6.275e+00	1	1.00e-04	6.275e+00	6.275e+00	1	1.00e-04	6.275e+00	6.275e+00	8	1.00e-04	6.275e+00	6.275e+00	8	1.00e-04	6.275e+00	6.275e+00																
ex7.3.3	1	1.00e-04	1.207e+00	1.207e+00	1	1.00e-04	1.207e+00	1.207e+00	1	1.00e-04	1.207e+00	1.207e+00	17	1.00e-04	1.207e+00	1.207e+00	17	1.00e-04	1.207e+00	1.207e+00																
ex7.3.5	0	1.00e-04	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	1	1.00e-04	0.000e+00	0.000e+00	1	1.00e-04	0.000e+00	0.000e+00																
ex8.1.1.3	7200	-	-	3.000e+01	13	-	3.000e+01	-	13	-	3.000e+01	-	7200	3.33e+11	-	3.000e+01	-	7200	3.33e+11	-																
ex8.1.1.4	0	1.00e-04	-1.032e+00	-1.032e+00	0	1.00e-04	-1.032e+00	-1.032e+00	0	1.00e-04	-1.032e+00	-1.032e+00	1	1.00e-04	-1.032e+00	-1.032e+00	1	1.00e-04	-1.032e+00	-1.032e+00																
ex8.1.1.5	0	2.26e-04	-1.000e+00	-1.000e+00	0	1.00e-04	-1.000e+00	-1.000e+00	0	1.00e-04	-1.000e+00	-1.000e+00	4	1.00e-04	-1.000e+00	-1.000e+00	4	1.00e-04	-1.000e+00	-1.000e+00																
ex8.1.1.6	5	1.00e-04	3.231e-02	3.231e-02	0	1.00e-04	3.231e-02	3.231e-02	0	1.00e-04	3.231e-02	3.231e-02	4	1.00e-04	3.231e-02	3.231e-02	4	1.00e-04	3.231e-02	3.231e-02																
ex8.1.1.7	7200	3.13e-02	-5.085e+00	-1.233e+00	7200	4.88e+01	-5.085e+00	-1.233e+00	7200	3.13e-02	-5.085e+00	-1.233e+00	7200	7.38e-07	-5.085e+00	-1.233e+00	7200	3.13e-02	-5.085e+00	-1.233e+00																
ex8.4.2	7200	5.47e-01	2.198e-01	4.852e-01	7200	4.88e+01	2.198e-01	4.852e-01	7200	2.08e+01	4.852e-01	2.198e-01	7200	2.08e+01	4.852e-01	2.198e-01	7200	5.47e-01	2.198e-01	4.852e-01																
ex8.4.3	7200	2.27e-01	4.639e-03	4.639e-03	7200	4.88e+01	4.639e-03	4.639e-03	7200	2.27e-01	4.639e-03	4.639e-03	7200	2.27e-01	4.639e-03	4.639e-03	7200	2.27e-01	4.639e-03	4.639e-03																
ex8.4.5	0	1.00e-04	3.065e-04	3.075e-04	3	1.00e-04	3.065e-04	3.075e-04	3	1.00e-04	3.065e-04	3.075e-04	3	1.00e-04	3.065e-04	3.075e-04	3	1.00e-04	3.065e-04	3.075e-04																
ark10003	63	1.00e-04	3.795e+03	3.795e+03	2928	4.88e+01	3.795e+03	3.795e+03	2928	4.88e+01	3.795e+03	3.795e+03	7200	2.98e+01	3.795e+03	3.795e+03	7200	63	3.795e+03	3.795e+03																
ark10006	33	1.00e-04	4.596e+00	4.596e+00	6307	1.00e-04	4.596e+00	4.596e+00	6307	1.00e-04	4.596e+00	4.596e+00	7200	2.98e+01	4.596e+00	4.596e+00	7200	33	4.596e+00	4.596e+00																
methanol100	715	-	-	9.022e-03	7200	1.00e-04	-	-	9.022e-03	7200	1.00e-04	-	-	9.022e-03	7200	1.00e-04	-	-	9.022e-03	7200																
methanol1200	504	-	-	9.022e-03	7200	1.00e-04	-	-	9.022e-03	7200	1.00e-04	-	-	9.022e-03	7200	1.00e-04	-	-	9.022e-03	7200																
methanol1400	1543	-	-	9.022e-03	7200	1.00e-04	-	-	9.022e-03	7200	1.00e-04	-	-	9.022e-03	7200	1.00e-04	-	-	9.022e-03	7200																
methanol1500	1997	-	-	9.022e-03	7200	1.00e-04	-	-	9.022e-03	7200	1.00e-04	-	-	9.022e-03	7200	1.00e-04	-	-	9.022e-03	7200																
minauf100	199	1.00e-04	2.507e+00	2.507e+00	97	1.00e-04	2.507e+00	2.507e+00	97	1.00e-04	2.507e+00	2.507e+00	7200	5.96e+01	2.507e+00	2.507e+00	7200	199	2.507e+00	2.507e+00																
minauf125	51	1.00e-04	2.519e+00	2.519e+00	4	1.00e-04	2.519e+00	2.519e+00	4	1.00e-04	2.519e+00	2.519e+00	7200	5.83e+01	2.519e+00	2.519e+00	7200	51	2.519e+00	2.519e+00																
minauf150	134	1.00e-04	2.506e+00	2.506e+00	145	1.00e-04	2.506e+00	2.506e+00	145	1.00e-04	2.506e+00	2.506e+00	7200	5.94e+01	2.506e+00	2.506e+00	7200	134	2.506e+00	2.506e+00																
minauf175	0	1.00e-04	-1.765e+00	-1.765e+00	0	1.00e-04	-1.765e+00	-1.765e+00	0	1.00e-04	-1.765e+00	-1.765e+00	2	1.00e-04	-1.765e+00	-1.765e+00	2	1.00e-04	-1.765e+00	-1.765e+00																
alkyl	1	1.00e-04	-1.979e+03	-1.979e+03	0	1.00e-04	-1.979e+03	-1.979e+03	0	1.00e-04	-1.979e+03	-1.979e+03	7200	2.43e-04	-1.979e+03	-1.979e+03	7200	1	-1.979e+03	-1.979e+03																
alkylation	0	1.00e-04	-1.979e+03	-1.979e+03	0	1.00e-04	-1.979e+03	-1.979e+03	0	1.00e-04	-1.979e+03	-1.979e+03	7200	2.43e-04	-1.979e+03	-1.979e+03	7200	0	-1.979e+03	-1.979e+03																
chain100	7200	9.83e-01	8.387e-02	5.076e+00	7200	2.45e+02	8.387e-02	5.076e+00	7200	9.83e-01	8.387e-02	5.076e+00	7200	5.30e+03	8.387e-02	5.076e+00	7200	7.14e+04	8.387e-02	5.076e+00																
chain200	7200	9.92e-01	4.234e-02	5.096e+00	7200	1.48e+02	4.234e-02	5.096e+00	7200	9.92e-01	4.234e-02	5.096e+00	7200	5.30e+03	4.234e-02	5.096e+00	7200	5.30e+03	4.234e-02	5.096e+00																
chain400	7200	9.86e-01	7.309e-02	5.096e+00	7200	1.52e+02	7.309e-02	5.096e+00	7200	9.86e-01	7.309e-02	5.096e+00	7200	1.37e+03	7.309e-02	5.096e+00	7200	5.30e+03	7.309e-02	5.096e+00																
chain500	7200	9.70e-01	1.528e-01	5.072e+00	7200	1.32e+02	1.528e-01	5.072e+00	7200	9.70e-01	1.528e-01	5.072e+00	7200	1.37e+03	1.528e-01	5.072e+00	7200	5.30e+03	1.528e-01	5.072e+00																
chakra	0	1.00e-04	-1.791e+02	-1.791e+02	2	1.00e-04	-1.791e+02	-1.791e+02	2	1.00e-04	-1.791e+02	-1.791e+02	0	1.00e-04	-1.791e+02	-1.791e+02	0	1.00e-04	-1.791e+02	-1.791e+02																
chance	0	1.00e-04	-1.791e+02	-1.791e+02	6	1.00e-04	-1.791e+02	-1.791e+02	6	1.00e-04	-1.791e+02	-1.791e+02	7200	7.68e-02	-1.791e+02	-1.791e+02	7200	0	-1.791e+02	-1.791e+02																
cheer	8	1.00e-04	2.109e+01	2.109e+01	1	1.00e-04	2.109e+01	2.109e+01	1	1.00e-04	2.109e+01	2.109e+01	7200	7.68e-02	2.109e+01	2.109e+01	7200	8	2.109e+01	2.109e+01																
elc200	7200	6.79e-01	1.429e+03	1.429e+03	7200	6.79e-01	1.429e+03	1.429e+03	7200	6.79e-01	1.429e+03	1.429e+03	7200	6.79e-01	1.429e+03	1.429e+03	7200	7.68e-02	1.429e+03	1.429e+03																
elc200	7200	1.00e-02	0.000e+00	0.000e+00	7200	6.79e-01	1.429e+03	1.429e+03	7200	1.00e-02	0.000e+00	0.000e+00																								

Table S24 (82 GLOBALLib Test Cases – Commercial Solvers) continued

Problem Name	MISO Framework			BARON 12.3.3			LINDO 8.0			
	Time	Gap	UB	Time	Gap	LB	Time	Gap	LB	UB
otpop	2	1.00e-04	-1.000e-06	0	1.00e-04	-1.000e-06	0	1.00e-04	0.000e+00	1.879e-19
plindyck	7200	1.21e+03	-1.529e+04	7200	1.00e+02	-2.455e+03	7200	6.24e+01	-1.901e+03	-1.170e+03
pollut	0	1.00e-04	-5.353e+06	0	1.00e-04	-5.353e+06	8	1.00e-04	-5.353e+06	-5.353e+06
prob07	31	1.00e-04	1.550e+05	13	1.00e-04	1.550e+05	1584	1.00e-04	1.550e+05	1.550e+05
prob09	0	1.00e-04	-1.000e-06	0	1.00e-04	-1.000e-06	0	1.00e-04	0.000e+00	6.091e-20
process	1	1.01e-04	-1.161e+03	0	1.00e-04	-1.161e+03	6	1.00e-04	-1.161e+03	-1.161e+03
zbrock	0	1.00e-04	-1.000e-06	0	1.00e-04	-1.000e-06	0	1.00e-04	0.000e+00	2.579e-22
sample	0	1.00e-04	7.267e+02	0	1.00e-04	7.267e+02	0	1.00e-04	7.267e+02	7.267e+02
srcpn	0	1.00e-04	2.110e+03	0	1.00e-04	2.110e+03	1	1.00e-04	2.110e+03	2.110e+03
zbrock	0	1.00e-04	-1.000e-06	0	1.00e-04	-1.000e-06	0	1.00e-04	0.000e+00	2.579e-22
sample	0	1.00e-04	7.267e+02	0	1.00e-04	7.267e+02	0	1.00e-04	7.267e+02	7.267e+02
srcpn	0	1.00e-04	2.110e+03	0	1.00e-04	2.110e+03	1	1.00e-04	2.110e+03	2.110e+03

Gap = $100 \cdot \left(\frac{UB-LB}{|LB|} \right)$; Termination Criteria: Gap = $1 \times 10^{-4}\%$ or Time = 7200 s

Table S25 (82 GLOBALLib Test Cases – Academic Solvers) continued

Problem Name	MISO Framework			SCIP 3.0			Couenne 0.4				
	Time	Gap	UB	Time	Gap	LB	Time	Gap	LB	UB	
otpop	2	1.00e-04	-1.000e-06	2.116e-18	0	1.00e-04	-1.001e-09	6.816e-08	1.00e-04	-1.990e-13	2.161e-22
plindyck	7200	1.21e+03	-1.529e+04	-1.170e+03	–	–	–	–	6.56e+01	-1.938e+03	-1.170e+03
pollut	0	1.00e-04	-5.353e+06	-5.353e+06	0	1.00e-04	-5.353e+06	-5.353e+06	1.00e-04	-5.353e+06	-5.353e+06
prob07	31	1.00e-04	1.550e+05	1.550e+05	–	–	–	–	–	–	–
prob09	0	1.00e-04	-1.000e-06	0.000e+00	0	1.00e-04	0.000e+00	0.000e+00	1.00e-04	1.199e-11	1.199e-11
process	1	1.01e-04	-1.161e+03	-1.161e+03	7200	3.22e+00	-1.199e+03	-1.161e+03	1.00e-04	-1.161e+03	-1.161e+03
zbrock	0	1.00e-04	-1.000e-06	2.045e-23	0	1.00e-04	0.000e+00	5.900e-18	1.00e-04	4.333e-19	4.333e-19
zbrock	0	1.00e-04	7.267e+02	7.267e+02	0	1.00e-04	7.267e+02	7.267e+02	1.00e-04	7.265e+02	7.265e+02
sample	0	1.00e-04	2.110e+03	2.110e+03	0	1.00e-04	2.110e+03	2.110e+03	7.46e-03	2.110e+03	2.110e+03
zbrock	0	1.00e-04	-1.000e-06	2.045e-23	0	1.00e-04	0.000e+00	5.900e-18	1.00e-04	4.333e-19	4.333e-19
zbrock	0	1.00e-04	7.267e+02	7.267e+02	0	1.00e-04	7.267e+02	7.267e+02	1.00e-04	7.265e+02	7.265e+02
sample	0	1.00e-04	2.110e+03	2.110e+03	0	1.00e-04	2.110e+03	2.110e+03	7.46e-03	2.110e+03	2.110e+03

Gap $\equiv 100 \cdot \left(\frac{UB-LB}{|LB|} \right)$; Termination Criteria: Gap = $1 \times 10^{-4}\%$ or Time = 7200 s

Table S26: 15 Other Test Cases – Commercial Solvers

Problem Name	MISO Framework				BARON 12.3.3				LINDO 8.0			
	Time	Gap	LB	UB	Time	Gap	LB	UB	Time	Gap	LB	UB
nltrens	0	1.00e-04	1.212e+06	1.212e+06	0	1.00e-04	1.212e+06	1.212e+06	1	1.00e-04	1.212e+06	1.212e+06
steelpl1	0	1.00e-04	-4.576e+05	-4.576e+05	0	1.00e-04	-4.576e+05	-4.576e+05	7200	2.18e+00	-4.675e+05	-4.576e+05
steelpl2	0	1.00e-04	1.643e+06	1.643e+06	0	1.00e-04	1.643e+06	1.643e+06	7200	1.14e+01	1.456e+06	1.643e+06
steelpl3	0	1.00e-04	2.939e+08	2.939e+08	0	1.00e-04	2.939e+08	2.939e+08	7200	5.08e+01	1.447e+08	2.939e+08
steelpl4	0	1.00e-04	-1.194e+06	-1.194e+06	0	1.00e-04	-1.194e+06	-1.194e+06	7200	1.00e-04	-1.194e+06	-1.194e+06
steelpl5	0	1.00e-04	-7.189e+05	-7.189e+05	0	1.00e-04	-7.189e+05	-7.189e+05	7200	3.25e+01	-9.38e+05	-7.189e+05
steelpl11	7200	7.72e-00	1.811e+05	1.811e+05	308	1.00e-04	1.962e+05	1.962e+05	7200	1.02e+01	1.76e+05	1.962e+05
esx001	0	1.00e-04	5.551e-01	5.551e-01	0	1.00e-04	5.551e-01	5.551e-01	0	1.00e-04	5.551e-01	5.551e-01
esx002	0	1.00e-04	8.000e+00	8.000e+00	0	1.00e-04	8.000e+00	8.000e+00	0	1.00e-04	8.000e+00	8.000e+00
esx003	0	1.00e-04	7.251e+00	7.251e+00	0	1.00e-04	7.251e+00	7.251e+00	0	1.00e-04	7.251e+00	7.251e+00
esx005	0	1.00e-04	-4.000e+00	-4.000e+00	0	1.00e-04	-4.000e+00	-4.000e+00	0	1.00e-04	-4.000e+00	-4.000e+00
ytz-2	0	1.00e-04	-9.990e-07	-9.990e-07	0	1.00e-04	-9.990e-07	-9.990e-07	1	1.00e-04	6.000e-10	0.000e+00
ytz-3	21	2.90e-01	1.002e+00	1.002e+00	7200	2.00e-01	1.002e+00	1.002e+00	96	1.00e-04	1.002e+00	1.002e+00
ytz-4	0	1.00e-04	1.000e+00	1.000e+00	0	1.00e-04	1.000e+00	1.000e+00	1	1.00e-04	1.000e+00	1.000e+00
ytz-5	0	1.00e-04	9.990e-04	9.990e-04	0	1.00e-04	9.990e-04	9.990e-04	1	1.00e-04	1.000e-03	1.000e-03

Gap $\equiv 100 \cdot \left(\frac{UB-LB}{|UB|} \right)$; Termination Criteria: Gap = 1×10^{-4} % or Time = 7200 s

Table S27: 15 Other Test Cases – Academic Solvers

Problem Name	MISO Framework				SCIP 3.0				Couenne 0.4			
	Time	Gap	LB	UB	Time	Gap	LB	UB	Time	Gap	LB	UB
nltrama	0	1.00e-04	1.212e+06	1.212e+06	7200	1.67e+00	1.192e+06	1.212e+06	936	1.73e-04	1.212e+06	1.212e+06
steelip11	0	1.00e-04	-4.576e+05	-4.576e+05	119	8.31e-04	-4.576e+05	-4.576e+05	-	-	-	-
steelip12	0	1.00e-04	1.643e+06	1.643e+06	7200	5.67e+02	-7.843e+06	1.681e+06	-	-	-	-
steelip13	0	1.00e-04	2.193e+08	2.193e+08	-	-	-1.194e+06	-1.194e+06	-	-	-1.194e+06	-1.194e+06
steelip14	0	1.00e-04	-1.109e+06	-1.109e+06	0	1.00e-04	-1.336e+06	-1.336e+06	7200	2.86e-00	-7.272e+05	-7.272e+05
steelip15	0	1.00e-04	-7.089e+05	-7.089e+05	0	1.23e+02	-6.755e+05	-6.755e+05	7200	4.97e+01	9.873e+04	9.873e+04
trcsteelip11	7200	7.72e+00	1.811e+05	1.962e+05	7200	4.33e+02	5.551e-01	1.995e+05	0	1.00e-04	5.551e-01	5.551e-01
ex001	0	1.00e-04	8.000e+00	8.000e+00	0	1.00e-04	8.000e+00	8.000e+00	0	1.00e-04	8.000e+00	8.000e+00
ex002	0	1.00e-04	8.000e+00	8.000e+00	0	1.00e-04	8.000e+00	8.000e+00	0	1.00e-04	8.000e+00	8.000e+00
ex003	0	1.00e-04	7.251e+00	7.251e+00	0	1.00e-04	7.251e+00	7.251e+00	0	1.00e-04	7.251e+00	7.251e+00
ex005	0	1.00e-04	-4.000e+00	-4.000e+00	0	1.00e-04	-4.000e+00	-4.000e+00	0	1.00e-04	-4.000e+00	-4.000e+00
ytz-2	0	1.00e-04	-9.990e-07	1.000e-09	0	1.00e-04	0.000e+00	1.000e-09	0	1.00e-04	1.000e-09	1.000e-09
ytz-3	21	2.00e-01	1.000e+00	1.002e+00	0	9.99e+01	9.990e-04	1.002e+00	0	1.00e-04	1.000e+00	1.000e+00
ytz-4	0	1.00e-04	1.000e+00	1.000e+00	0	1.00e-04	1.000e+00	1.000e+00	0	1.00e-04	1.000e+00	1.000e+00
ytz-5	0	1.00e-04	9.990e-04	1.000e-03	7200	-	1.000e-03	1.000e-03	0	1.00e-04	1.000e-03	1.000e-03

Cap $\equiv 100 \cdot \left(\frac{UB-LB}{|UB|} \right)$; Termination Criteria: Gap = $1 \times 10^{-4}\%$ or Time = 7200 s